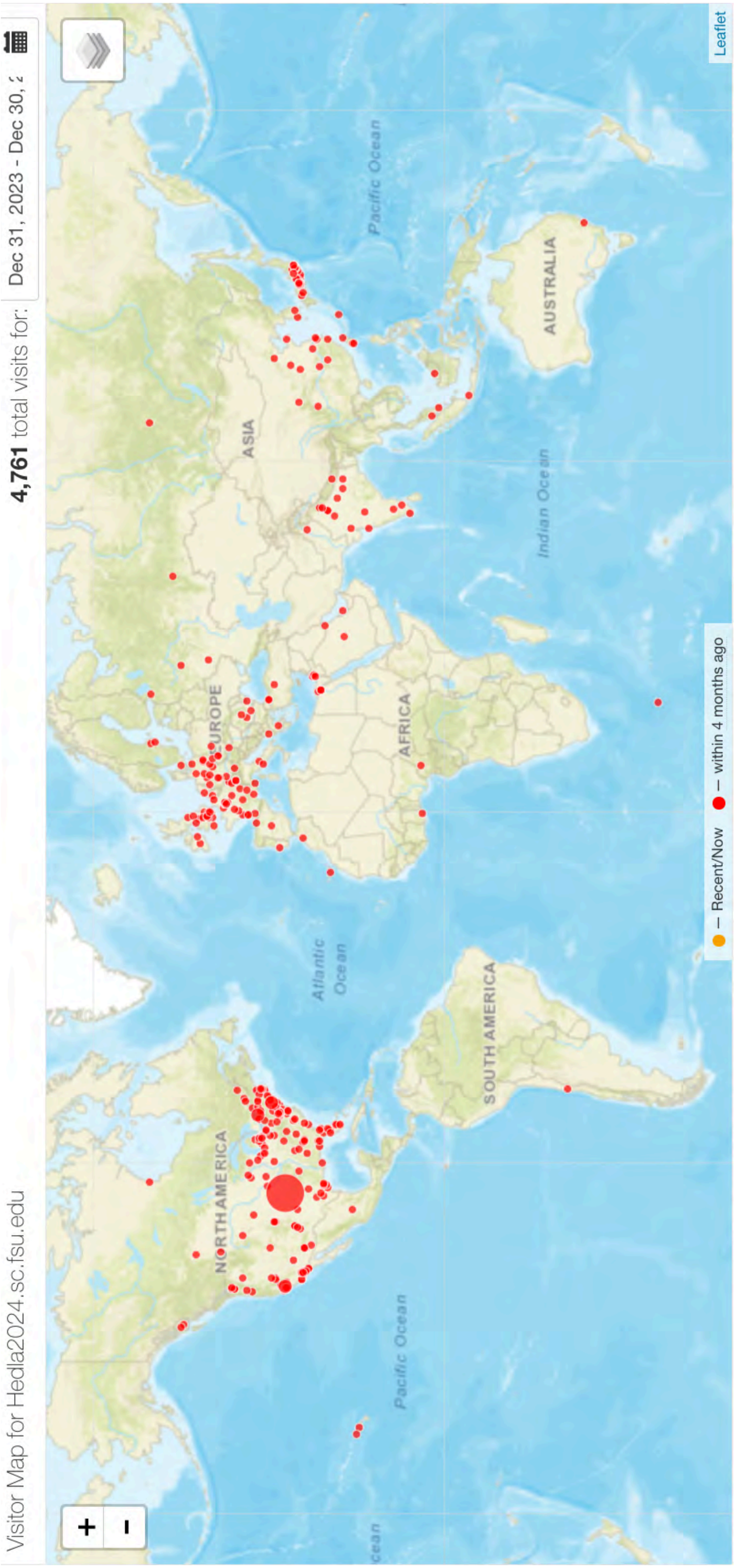
HEDLA 2024

14th International Conference on High Energy Density Laboratory Astrophysics
Tallahassee, Florida, May 20 – May 24, 2024

The HEDLA 2024 conference is jointly sponsored by the US DOE National Nuclear Security Administration, Japan Society for the Promotion of Science, the Florida State University, and the Tourism Development Department of Leon County.



Country	Locations	Visits	Unique
United States	206 Locations	3,182	1,807
Japan	39 Locations	658	313
France	24 Locations	357	155
United Kingdom	18 Locations	203	126
Germany	15 Locations	84	66
Canada	6 Locations	39	25
India	14 Locations	33	25
China	12 Locations	29	25
Czech Republic	2 Locations	22	10
Romania	4 Locations	16	13
Ghana		15	4
Egypt	4 Locations	14	8
Denmark		10	6
Israel	3 Locations	9	7
Ireland	2 Locations	9	5
Portugal	Lisbon	8	4
Russia	5 Locations	7	7
Sweden	2 Locations	7	4

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Dan Casey (LLNL)
Marcus Knudson (SNLA)
Alexis Casner (University of Bordeaux)
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Abigail Armstrong, Los Alamos National Laboratory
Tristan Bachmann, University of Rochester
James Bailey, Sandia National Laboratories
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Tilo Doeppner, Lawrence Livermore National Laboratory
Lea Dollerschell, CEA-DAM-DIF
Tobias Dornheim, Helmholtz-Zentrum Dresden-Rossendorf
Forrest Doss, Los Alamos National Laboratory
Emeric Falize, CEA-DAM-DIF
Marin Fontaine, CEA-DAM-DIF
Margaux François, University of Bordeaux
Mungo Frost, SLAC, Stanford University
Julien Fuchs, LULI, CNRS
Shinsuke Fujioka, Osaka University
Jhonnatan Gama Vazquez, SLAC, Stanford University
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Patrick Hartigan, Rice University
Hannah Hasson, Sandia National Laboratories
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Haibo Huang, General Atomics
Isaac Huegel, University of Michigan
Megan Ikeya, SLAC, Stanford University
Amy Jenei, Lawrence Livermore National Laboratory
Hantao Ji, Princeton University
Taiki Jikei, The University of Tokyo
Yong-Jae Kim, Lawrence Livermore National Laboratory
Dominik Kraus, Universität Rostock
Andrew Krygier, Lawrence Livermore National Laboratory

HEDLA 2024 Participants (cont.)

Yasuhiro Kuramitsu, Osaka University
Kiyochika Kuramoto, Osaka University
Carolyn Kuranz, University of Michigan
Kelin Kurzer-Ogul, Los Alamos National Laboratory
Olin Ou, Labun, The University of Texas, Austin
Lance Labun, The University of Texas, Austin
Sergey Lebedev, Imperial College London
Heath LeFevre, University of Michigan
Kirill Lezhnin, Princeton Plasma Physics Laboratory
Chikang Li, Massachusetts Institute of Technology
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Dalton Lund, Cornell University
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Mikhail Medvedev, The University of Kansas
Elizabeth Merritt, Los Alamos National Laboratory
Akira Mizuta, RIKEN
Kasper Moczulski, University of Rochester
Ananya Mohapatra, University of Rochester
Zhandos Moldabekov, CASUS, Helmholtz-Zentrum Dresden-Rossendorf
Mamiko Nishiuchi, National Institutes for Quantum Science and Technology
Robert Nowak, LLE, University of Rochester
Ivan Oleynik, University of South Florida
Luca Orusa, Princeton University
Hye-Sook Park, Lawrence Livermore National Laboratory
Stylianos Passalidis, CEA-DAM-DIF
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Gabriel Rigon, Massachusetts Institute of Technology
Brandon Russell, Massachusetts Institute of Technology
Mateusz Ruszkowski, University of Michigan
Ryan Rygg, University of Rochester

HEDLA 2024 Participants (cont.)

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Kentaro Sakai, National Institute for Fusion Science
Ruben Santana, General Atomics
Derek Schaeffer, University of California, Los Angeles
Sarah Shores Prins, University of Nevada, Reno
Jaya Sicard, University of Nevada, Reno
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David Stark, William & Mary
Terry-Ann Suer, LLE, University of Rochester
George Swadling, Lawrence Livermore National Laboratory
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Daisuke Tanaka, ILE, Osaka University
Victor Tranchant, University of Rochester
Matthew Trantham, University of Michigan
Eleanor Tubman, Imperial College London
Petros Tzeferacos, University of Rochester
Vincent Valenzuela-Villaseca, Princeton University
Timothy Van Hoomissen, University of California, Los Angeles
Arno Vanthieghem, CNRS, Sorbonne University
Alexander Velikovich, U.S. Naval Research Laboratory
Thomas Vincent, University of Oxford
Sam Vinko, University of Oxford
Michael Wadas, California Institute of Technology
Yuyao Wang, University of York
Jaela Whitfield, University of Michigan
June Wicks, Johns Hopkins University
Victor Yu Zhang, LLE, University of Rochester
Yangyuxin (Amy) Zou, University of Rochester

HEDLA 2024 Conference Photo

Thursday afternoon

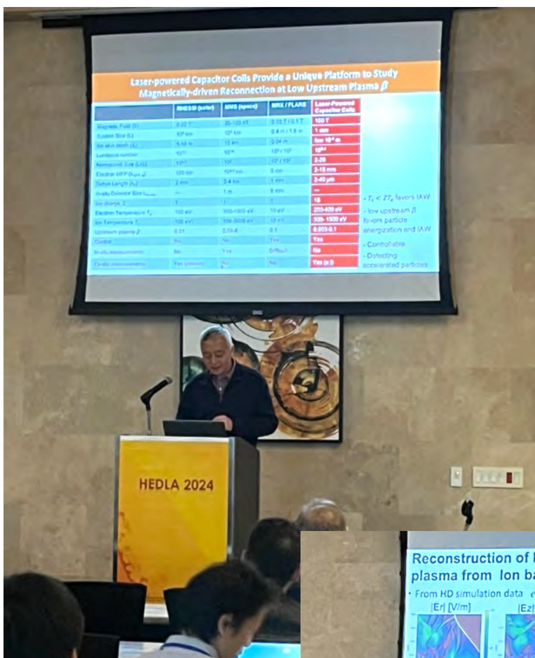
HEDLA 2024 Local Organizing Committee at work

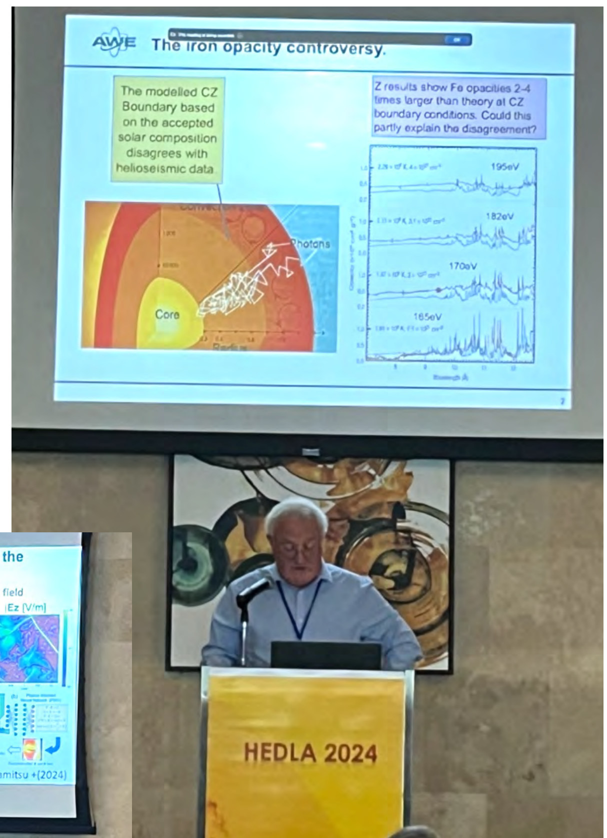
HEDLA 2024 Conference Banquet

Speaker: Daniel Casey (LLNL)

All photographs on this page courtesy Kendall Cooper/FSU College of Arts and Sciences.

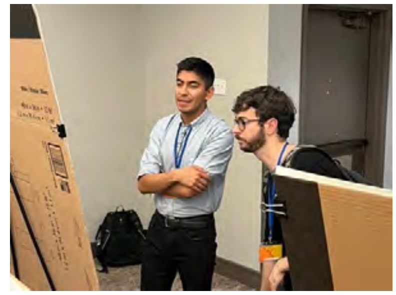
HEDLA 2024 Plenary Sessions





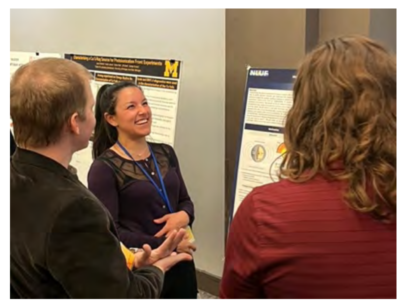
HEDLA 2024 Poster Session

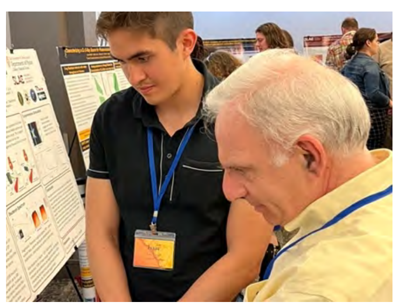
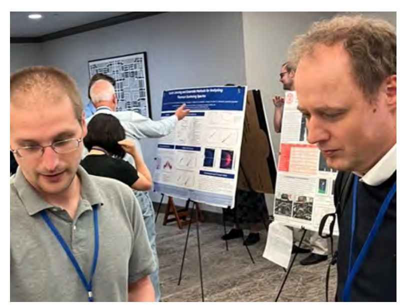


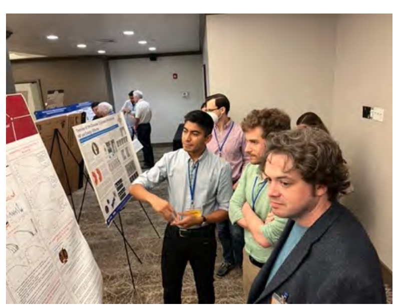




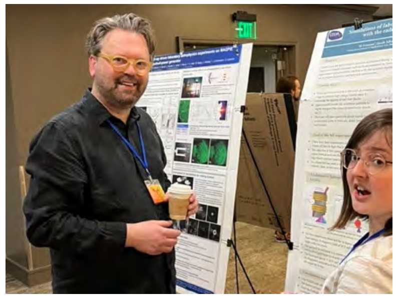
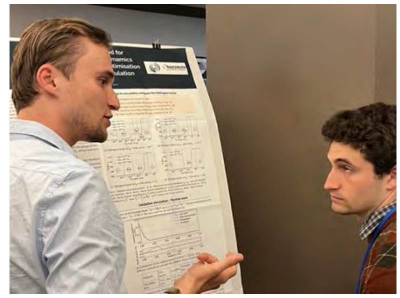
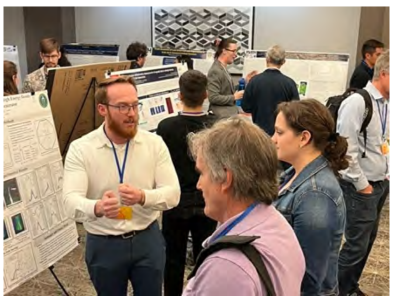


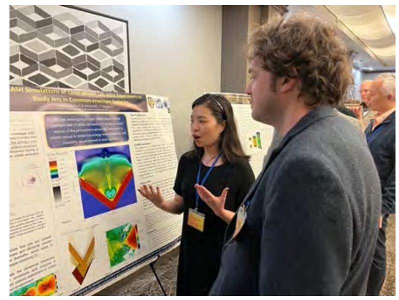


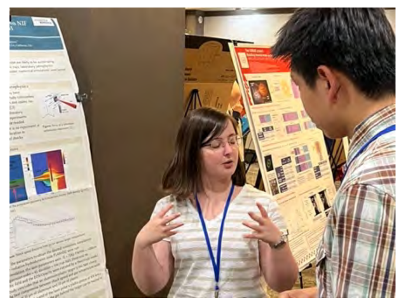
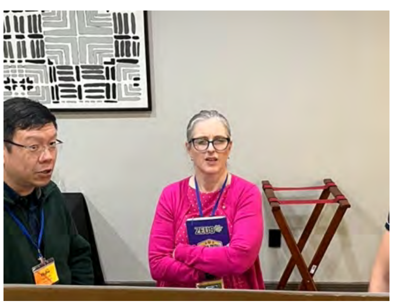






HEDLA 2024 Poster Session (cont.)




HEDLA 2024 Coffee Breaks

HEDLA-2024: THE 14TH INTERNATIONAL CONFERENCE ON HIGH ENERGY DENSITY LABORATORY ASTROPHYSICS

PROGRAM | AUTHORS | KEYWORDS

PROGRAM

Days: Sunday, May 19th Monday, May 20th Tuesday, May 21st Wednesday, May 22nd Thursday, May 23rd Friday, May 24th

Sunday, May 19th

View this program: with abstracts session overview talk overview

17:45-20:00 Session 1: Registration

Registration

LOCATION: Horizon Grand Ballroom

18:00-20:00 Reception

Reception

LOCATION: Horizon Grand Ballroom

Monday, May 20th

View this program: with abstracts session overview talk overview

06:45-08:00 Session 2: Breakfast

LOCATION: Shula Grill Restaurant

08:00-08:05 Session 3: Announcements

CHAIR: *Local Organizing Committee*
LOCATION: Horizon Grand Ballroom

08:05-08:35 Session 4: Perspectives and Insights

CHAIR: *Tomasz Plewa*
LOCATION: Horizon Grand Ballroom

08:05 *R. Paul Drake*
The History and Value of HEDLA

08:20 *Bruce Remington*
HEDLA at the Extreme

08:35-10:00 Session 5: Materials at High Pressures I

CHAIR: *Ryan Rygg*
LOCATION: Horizon Grand Ballroom

08:35 *Dominik Kraus*
Light Elements at Mbar to Gbar Pressures (abstract)

08:55 *Ivan Oleynik*
Extreme Metastability of Diamond and Its Transformation to BC8 Post-Diamond Phase of Carbon (abstract)

09:15 *Mungo Frost*, *R Stewart McWilliams*, *Siegfried Glenzer* and *Alexander Goncharov*
Diamond Precipitation Dynamics from Hydrocarbons at Icy Planet Interior Conditions (abstract)
PRESENTER: *Mungo Frost*

09:35 *Martin Preising*, *Martin French*, *Christopher Mankovich*, *François Soubiran* and *Ronald Redmer*
Material Properties of Saturn'S Interior from Ab Initio Simulations (abstract)
PRESENTER: *Martin Preising*

10:00-10:30 Coffee Break

10:30-12:00 Session 6: Supernovae, Hydrodynamic Instabilities, and Shocks

CHAIR: *Alexander Velikovich*
LOCATION: Horizon Grand Ballroom

10:30 *Bruce Remington*
New Regimes of Frontier Science on the National Ignition Facility (abstract)

10:42 *Tomasz Plewa*, *Andrey Zhiglo*, *Ezra Brooker*, *Brandon Gusto* and *Ryan Learn*
Thermonuclear Turbulent Combustion in Type Ia Supernovae (abstract)
PRESENTER: *Tomasz Plewa*

11:02 *Carolyn Kuranz*, *Heath LeFevre*, *Matthew Trantham*, *Eric Johnsen*, *Griffin Cearly*, *Kevin Ma*, *Hye-Sook Park*, *Michael MacDonald*, *Marius Millot* and *Tilo Doeppner*

Creating Astrophysically Relevant Systems in the Laboratory in the High-Energy-Density Regime (abstract)
PRESENTER: *Carolyn Kuranz*

11:22 *Mateusz Ruszkowski*
Impact of Cosmic Rays on Galaxy Evolution (abstract)

11:42 *Arno Vanthieghem*, *Vassilis Tsiolis*, *Anatoly Spitkovsky*, *Yasushi Todo*, *Kazuhiro Sekiguchi* and *Frederico Fiuza*
The Electron-Ion Temperature Ratio: from Newtonian to Relativistic Weakly Magnetized Shock Waves (abstract)
PRESENTER: *Arno Vanthieghem*

12:00-13:30 Lunch Break

13:30-15:10 Session 7: Collisionless Shocks

CHAIR: *Carolyn Kuranz*
LOCATION: Horizon Grand Ballroom

13:30 *Hye-Sook Park*, *E. Tubman*, *F. Fiuza*, *C. Bruulsema*, *D. Higginson*, *D. Larson*, *M. Manuel*, *K. Moczulski*, *M. Pokornik*, *B. Pollock*, *D. Ryutov*, *G. Swadling* and *P. Tzeferacos*
Study of Astrophysical Collisionless Shocks in the Laboratory (abstract)
PRESENTER: *Hye-Sook Park*

13:50 *George Swadling*
From Microscale Physics to Astrophysical-Scale Effects: Using Experiments on Omega and the NIF to Unravel the Enduring Enigma of Astrophysical Collisionless Shocks (abstract)

14:10 *Eleanor Tubman*, *Hye-Sook Park*, *David Larson*, *Drew Higginson*, *Bradley Pollock*, *George Swadling*, *Colin Bruulsema*, *Brent Blue*, *Petros Tzeferacos*, *Kasper Moczulski*, *Michael Pokornik*, *Mario Manuel* and *Frederico Fiuza*
Measuring Reflected Ions in the Upstream of a Magnetised, Collisionless Shock. (abstract)
PRESENTER: *Eleanor Tubman*

14:30 *Emeric Falize*, *Lea Dollerschell*, *Marin Fontaine*, *Christopher Bowen*, *Clotilde Busschaert*, *Nicolas Charpentier*, *Andrea Ciardi*, *Jean-Christophe Pain*, *Victor Tranchant* and *Lucile Van Box Som*
From Dimensional Analysis to Mapping Transformations: Scalability of Astrophysical Flows in Accretion-Explosion Environments (abstract)
PRESENTER: *Emeric Falize*

14:42 *James Beattie*
The Compressible Turbulent Dynamo (abstract)

14:54 *Mikhail Medvedev*
Quasi-Nonlinear Approach to the Weibel Instability in the Upstream Medium of a Collisionless GRB Shock (abstract)

15:10-15:40 Coffee Break

15:40-17:20 Session 8: Fusion & Particle Acceleration

CHAIR: *Mamiko Nishiuchi*
LOCATION: Horizon Grand Ballroom

15:40 *Daniel Casey*
Thermonuclear Reactions Probed at Stellar Core Conditions with Laser-Based Inertial Confinement Fusion* (abstract)

16:00 *Shinsuke Fujioka*, *Hiroki Matsubara*, *Yuga Karaki*, *Ryuya Yamada*, *Takumi Tsuido*, *Ryunosuke Takizawa*, *Farley Law*, *Keisuke Takahashi*, *Koichi Honda*, *Kohei Yamanoi*, *Matt Wang*, *Takumi Minami*, *Tomoyuki Johzaki*, *Seita Iizuka*, *Toshiharu Yasui*, *Akifumi Yogo*, *Fuka Nikaido*, *Yuji Fukuda*, *Takehito Hayakawa*, *Yuki Abe*, *Atsushi Sunahara*, *Masato Kanasaki*, *Yasuhiro Kuramitsu*, *Hiroaki Ohta* and *Shuji Nakamura*
Mutliple Diagnostics of Proton-Boron Fusion Reactions in High-Eneregy-Density Plasma (abstract)
PRESENTER: *Shinsuke Fujioka*

16:20 *Farhat Beg*, *Mathieu Bailly-Grandvaux*, *Joowan Kim*, *Chris McGuffey*, *Krish Bhutwala*, *Jacob Saret* and *Phil Nilson*
Energetic Proton Beam Heating of Targets Relevant to Proton Fast Ignition (abstract)
PRESENTER: *Farhat Beg*

16:40 *David Stark*
Evolution of Relativistic Self-Focusing of Laser Pulses in near-Critical Density Plasmas (abstract)

16:52 *Lance Labun*
Searching for Unruh Radiation in the Lab (abstract)

17:04 *Gonzague Radureau* and *Claire Michaut*
New Computational Method for Multigroup Radiative Hydrodynamics Using Artificial Intelligence: Analysis of Radiative Shock Structure (abstract)
PRESENTER: *Gonzague Radureau*

Tuesday, May 21st

View this program: with abstracts session overview talk overview

06:45-08:00 Session 9: Breakfast

LOCATION: Shula Grill Restaurant

08:00-08:05 Session 10: Announcements

CHAIR: *Local Organizing Committee*
LOCATION: Horizon Grand Ballroom

08:05-09:30 Session 11: Atomic Physics at High Pressures

CHAIR: *Dominik Kraus*
LOCATION: Horizon Grand Ballroom

08:05 *Tilo Doeppner*
Observing the Onset of Pressure-Driven K-Shell Delocalization (abstract)

08:25 *Mike MacDonald*, *Carlos Di Stefano*, *Tilo Doeppner*, *Luke Fletcher*, *Kirk Flippo*, *Dan Kalantar*, *Elizabeth Merritt*, *Suzanne Ali*, *Peter Celliers*, *Rick Heredia*, *Scott Vonhof*, *Rip Collins*, *Jim Gaffney*, *Dirk Gericke*, *Siegfried Glenzer*, *Dominik Kraus*, *Alison Saunders*, *Derek Schmidt*, *Christopher Wilson*, *Rich Zacharias* and *Roger Falcone*
The Colliding Planar Shocks Platform to Study Warm Dense Matter and Laboratory Astrophysics at the National Ignition Facility (abstract)
PRESENTER: *Mike MacDonald*

08:45 *Tobias Dornheim*
Breaking the Vicious Cycle of Warm Dense Matter Diagnostics (abstract)

09:05 *David Bishel*, *Philip Nilson*, *D. Alexander Chin*, *John Ruby*, *Ethan Smith*, *Edward Marley*, *Reuben Epstein*, *Suxing Hu*, *Igor Golovkin*, *Ming Gu*, *J. Ryan Rygg* and *Gilbert Collins*
Dense Plasma Line Shifts of Inner-Shell Transitions (abstract)
PRESENTER: *David Bishel*

09:30-10:00 Coffee Break

10:00-11:45 Session 12: Magnetized Plasma and Experimental Platforms

CHAIR: *Bruce A. Remington*
LOCATION: Horizon Grand Ballroom

10:00 *Felicie Albert*
The Jupiter Laser Facility: a Kilojoule-Class Laser for Producing and Exploring Extreme States of Matter (abstract)

10:20 *Alexander Velikovich*, *Calvin Zulick*, *Yefim Aglitskiy*, *Max Karasik* and *Andrew Schmitt*
Turbulence in Shock Interaction with Density Inhomogeneities and Foam Hugoniot Experiments on the Nike Laser Facility (abstract)
PRESENTER: *Alexander Velikovich*

10:40 *Pablo J. Bilbao*, *Charles D. Arrowsmith*, *Jack Halliday*, *Vasiliki Stergiou*, *Sifei Zhang*, *Thales Silva*, *Bruno Buonomo*, *Fabio Cardelli*, *Eleonora Diociaiuti*, *Domenico di Giovenale*, *Claudio di Giulio*, *Luca Fogetta*, *Robert Bingham*, *Luis O. Silva* and *Gianluca Gregori*
Laboratory Analogues of Astrophysical Coherent Electron Cyclotron Maser Processes (abstract)
PRESENTER: *Pablo J. Bilbao*

11:00 *Sergey Lebedev*
Experiments with Pulsed-Power Driven High Energy Density Magnetized Plasmas: Rotation, Turbulence and Shocks (abstract)

11:20 *Patrick Poole*, *Tanim Islam*, *Robert Tipton* and *Joe Wasem*
Developing X-Ray Sources for Plantary Defense Studies at Omega and NIF (abstract)
PRESENTER: *Patrick Poole*

11:32 *Katherine Marrow*, *Stefano Merlini*, *Jergus Strucka*, *Aidan Crilly*, *Benjamin Duhig*, *Thomas Mundy*, *Jack Halliday*, *Lee Suttle*, *Jerry Chittenden* and *Sergey Lebedev*
X-Ray Driven Laboratory Astrophysics Experiments on MAGPIE Pulsed-Power Generator (abstract)
PRESENTER: *Katherine Marrow*

12:00-13:30 Lunch Break

13:30-15:10 Session 13: Materials at High Pressures II

CHAIR: *Ivan Oleynik*
LOCATION: Horizon Grand Ballroom

13:30 *Danae Polsin*, *Amy Jenei*, *Andy Krygier*, *Xuchen Gong*, *Stephen Burns*, *Federica Coppari*, *Linda Hansen*, *Margaret Huff*, *Malcolm McMahon*, *Marius Millot*, *Reetam Paul*, *Raymond Smith*, *Jon Eggert*, *Eva Zurek*, *Matthew Signor*, *Zechen Liu*, *Kevin Vencatasamy*, *G. W. Collins* and *J. R. Rygg*
Structural Complexity in Ramp-Compressed Sodium to 480 GPa (abstract)
PRESENTER: *Danae Polsin*

13:50 *Kyla de Villa*, *Felipe Gonzalez-Cataldo* and *Burkhard Militzer*
Proton Superionicity and Double Superionicity in Planetary Ices (abstract)
PRESENTER: *Kyla de Villa*

14:10 *Terry-Ann Suer*, *Stephanie Brygoo*, *Grigory Tabak*, *Shuai Zhang*, *Michelle Marshall*, *Ryan Rygg*, *Paul Loubeyre*, *Gilbert Collins* and *Raymond Jeanloz*
Shock Compression of H-Rich Mixtures at Giant Planet Interior Conditions (abstract)
PRESENTER: *Terry-Ann Suer*

14:30 *Ryan Rygg*

Anomalous Sound Speed in Warm Dense Matter (abstract)

14:50 *Zhandos Moldabekov*
Dynamic Structure Factor and Dielectric Properties of Warm Dense Hydrogen Form Linear-Response Time-Dependent Density Functional Theory (abstract)

15:10-15:40 Coffee Break

15:40-17:30 Session 14: Poster Session

LOCATION: Opal Room

Abigail Armstrong, *Joshua Sauppe*, *Hui Li*, *Elizabeth Merritt*, *Adam Reyes*, *Edward Hansen* and *Petros Tzeferacos*
FLASH Simulations of Biermann-Generated Magnetic Field in a Convergent System (abstract)

Tristan Bachmann, *Jessica Pilgram*, *Marissa Adams*, *Mario Manuel*, *Carmen Constantin*, *Haiping Zhang*, *Lucas Rovige*, *Peter Heuer*, *Robert Dorst*, *Sofiya Ghazaryan*, *Marietta Kaloyan*, *Derek Schaeffer*, *Christoph Niemann* and *Petros Tzeferacos*
Laboratory Astrophysics Exploration of Early Universe Magnetogenesis via Biermann Battery (abstract)

Léa Dollerschell, *Lucile Van Box Som*, *Bruno Albertazzi*, *Anabella Araudo*, *Clotilde Busschaert*, *Alexis Casner*, *Nicolas Charpentier*, *Ronan Devriendt*, *Marin Fontaine*, *Thibault Goudal*, *Manuel Jullien*, *Yann Marchenay*, *Diego Oportus*, *Bruno Peres*, *Gabriel Rigon*, *Youichi Sakawa*, *Angelos Triantafyllidis* and *Emeric Falize*
The CIRENE Project : Modeling Internal Novæ Ejectas Radiative Shocks in the Laboratory. (abstract)

Margaux François, *Derek Schaeffer*, *Jean-Luc Dubois*, *Emmanuel D'Humières* and *Xavier Ribeyre*
Preparatory Simulations with FLASH of a Laboratory Astrophysics Experiment on the NIF Laser-Facility (abstract)

Thomas Gawne, *Hannah Bellenbaum*, *Luke B Fletcher*, *Thomas R Preston*, *Oliver S Humphries*, *Dominik Kraus*, *Michael J MacDonald*, *Zhandos A Moldabekov*, *Chongbing Qu*, *Jan Vorberger* and *Tobias Dornheim*
Effects of Mosaic Crystal Instrument Functions on X-Ray Thomson Scattering Diagnostics (abstract)

Xuchen Gong, *Michelle Marshall*, *Mary Kate Ginnane*, *J. Ryan Rygg* and *Gilbert W. Collins*
Extending Sub-Nanosecond Optical Pyrometry Temperature Measurement to <4000 K (abstract)
PRESENTER: *Xuchen Gong*

Hannah Hasson, *Irem Nesli Erez*, *Imani West-Abdallah*, *James Young*, *Jay Angel*, *Chiatai Chen*, *Euan Freeman*, *John B. Greenly*, *David A. Hammer*, *Eric Sander Lavine*, *William M. Potter* and *Pierre-Alexandre Gourdain*
Rotating Plasma Outflows with Tunable Magnetic Fields Resembling YSO (abstract)

Haibo Huang, *Kevin Sequoia*, *Ruben Santana*, *Masashi Yamaguchi*, *Pavel Lapa*, *Neal Tomlin* and *Michael Farrell*
Solar Opacity Motivated AutoEdge Xray Opacity Measurement, X-Ray Database Revision, and Validation by RBS Method (abstract)

Isaac Huegel, *Patricia Cho*, *Heath LeFevre*, *Matthew Trantham*, *Guillaume Loisel* and *Carolyn Kuranz*
Radiation Hydrodynamics Simulations of the Photoionized Expanding Foil Experiment on Z (POSTER PRESENTATION) (abstract)

Megan Ikeya, *E. Rebeca Toro-Garza*, *Siegfried Glenzer* and *Benjamin Ofori-Okai*
Electrical Conductivity of Warm Dense Nickel Studied by Single-Shot Terahertz Spectroscopy (abstract)

Kiyochika Kuramoto, *Shuta Tanaka*, *Kentaro Sakai*, *Yuki Abe*, *Kosuke Himeno*, *Kazumasa Oda*, *Soichiro Suzuki*, *Fuka Nikaido*, *Toshiharu Yasui*, *Tatiana Pikuz*, *Takafumi Asai*, *Masato Kanasaki*, *Reona Ozaki*, *Keita Toyonaga*, *Hajime Maekawa*, *Hiromitsu Kiriyama*, *Akira Kon*, *Kotaro Kondo*, *Wei-Yen Woon*, *Che-Men Chu*, *Kuan-Ting Wu*, *Chun-Sung Jao*, *Yao-Li Liu*, *Shogo Isayama*, *Hideki Kohri*, *Atsushi Tokiyasu*, *Harihara Sudhan Kumar*, *Takumi Minami*, *Yuji Fukuda* and *Yasuhiro Kuramitsu*
Comparison Between Induced Compton Scattering Experiments and Particle-in-Cell Simulation (abstract)

Ou Labun
High Neutron Flux, High Deuteron and Neutron Yields from the Interaction of a Petawatt Laser with a Cryogenic Deuterium Jet (abstract)

Heath LeFevre, *Julian Kinney*, *Piper Halcrow*, *Ryan McClarren*, *Scott Baalrud* and *Carolyn Kuranz*
Creating Neutron Star Envelope Conditions Using the Omega-60 Laser (abstract)

Dalton Lund, *Eric Lavine*, *Euan Freeman*, *Chiatai Chen*, *Charles Seyler* and *Bruce Kusse*
Dynamics and Stability of Magnetically Driven High Energy Density Plasma Jets on the 1-MA COBRA Generator (abstract)

Katherine Marrow, *Howard Chen*, *Yiyang Ding*, *Lee Suttle*, *Stefano Merlini*, *Jergus Strucka*, *Thomas Mundy*, *Benjamin Duhig* and *Sergey Lebedev*
Radiative Cooling Effects in X-Ray Driven Plasma Jets from Wedge Targets (abstract)

Kasper Moczulski, *Han Wen*, *Thomas Campbell*, *Jack Halliday*, *Anthony Scopatz*, *Charlotte A. J. Palmer*, *Archie F. A. Bott*, *Charlie D. Arrowsmith*, *Abel Blazevic*, *Vincent Bagnoud*, *Scott Feister*, *Oliver Karnback*, *Martin Metternich*, *Haress Nazary*, *Paul Neumayer*, *Adam Reyes*, *Edward Hansen*, *Dennis Schumacher*, *Christopher Spindloe*, *Subir Sarkar*, *Anthony R. Bell*, *Robert*

Bingham, Francesco Miniati, Alexander A. Schekochihin, Brian Reville, Don Q. Lamb, Gianluca Gregori and Petros Tzeferacos
Numerical Simulations of Laser-Driven Experiments of Ion Acceleration in Stochastic Magnetic Fields (abstract)

Ananya Mohapatra, Abigail Armstrong, Eddie Hansen, Kasper Moculski, Archie Bott, Adam Reyes, Eric Blackman and Petros Tzeferacos
Hall-MHD in Driven Turbulence FLASH Simulations (abstract)

Robert Nowak, Gerrit Bruhaug, Jiacheng Zhao, Yiwen E, Xi-Cheng Zhang, Gilbert Collins and Ryan Rygg
Towards THz Time Domain Spectroscopy on the Omega Laser Facility (abstract)

Stylianos Passalidis, Yuliia Mankovska, Max Gilljohann, Olena Kononenko, Pablo San Miguel Claveria, Ludovic Lecherbourg, Xavier Davoine, Sebastien Corde and Laurent Gremillet
Modelling Electron Deflectometry Measurements of Magnetic Fields in Ultrahigh-Intensity, Femtosecond Laser-Foil Interactions (abstract)

Gonzague Radureau and Claire Michaut
New Computational Method for Multigroup Radiative Hydrodynamics Using Artificial Intelligence: Optimisation of the Eddington Factor Calculation (abstract)

Emily Rettich, Colin Bruulsema, Anna Grassi, Frederico Fiuza, Wojciech Rozmus and George Swadling
Strong B-Fields Observed in Ion-Weibel Filamented Counter-Streaming Laser-Driven Plasma (abstract)

Irina Sagert, Joshua P. Sauppe, John L. Kline, Kirk A. Flippo, Lynn Kot, James F. Dowd, Thomas H. Day and Derek W. Schmidt
Overview of the Double Cylinder Platform for NIF and Design Efforts (abstract)

Ruben Santana, Carlos Monton, Haibo Huang, Kevin Sequoia, Neal Tomlin and Michael Farrell
Fabrication of Thick Oxide and Metal Foils for Solar Opacity Motivated High Energy Density Experiments (abstract)

Sarah Shores Prins, Cameron Allen, Laurent Divol, Ryan Enoki, Dirk Gericke, Landon Morrison, Matthew Oliver, Yuan Ping, Nathaniel Schaffer, Markus Schoelmerich, Tilo Doeppner and Thomas White
Measuring the Thermal Conductivity of Iron Alloys Under Planetary Core Conditions at the OMEGA Laser Facility (abstract)

Jaya Sicard, Travis Griffin, Thomas White, Daniel Haden, Bob Nagler, Hae Ja Lee, Eric Galtier, Dimitri Khagani, Sameen Yunus, Eric Cunningham, Jerome Hastings, Jacob Molina, Siegfried Glenzer, Emma Mcbride, Luke Fletcher, Giulio Monaco, Ulf Zastrau, Karen Appel, Sebastian Goede, Lennart Wollenweber, Dirk Gericke, Gianluca Gregori, Carson Convery, Adrien Descamp and Jeremy Iratcabal
Electron-Ion Equilibration Rates in Warm Dense Metals (abstract)

Naoya Tamaki, Takumi Minami, Soichiro Suzuki and Yasuhiro Kuramitsu
Optimization of Ion Acceleration by Irradiating Large-Area Suspended Graphene with an Intense Laser (abstract)

Matthew Trantham, Derek Shaeffer, Mirielle Wong and Carolyn Kuranz
A Study Using Flash to Evaluate a Collisionless Shock Experiment on Z (abstract)

Vicente Valenzuela-Villaseca, Jacob M. Molina, Derek B. Schaeffer, Sophia Malko, Jesse Griff-McMahon, Kirill Lezhnin, Michael J. Rosenberg, Suxing H. Xu, Dan Kalantar, Clement Trosseille, Hye-Sook Park, Bruce A. Remington, Gennady Fiksel, Dmitri Uzdensky, Amitava Bhattacharjee and Will Fox
X-Ray Imaging and Electron Temperature Evolution in Laser-Driven Magnetic Reconnection Experiments at the NIF (abstract)

Timothy Van Hoomissen, Samuel Eisenbach, Derek Mariscal, Robert Dorst, Derek Schaeffer, Alejandro Ortiz, Haiping Zhang, Lucas Rovige, Christoph Niemann, Carmen Constantin and Jessica Pilgram
Transfer Learning Approaches for Analyzing Two-Dimensional Thomson Scattering Spectra from Laser-Produced Plasmas (abstract)

Jhonnatan Gama Vazquez, Frederico Fiuza, Alexis Marret and Siegfried Glenzer
Simulation Study of Energy Partition and Particle Injection in Magnetized Collisionless Shocks (abstract)

Jaela Whitfield, Heath LeFevre, Sallee Klein, Jill Schell and Carolyn Kuranz
Characterizing a Cu X-Ray Source for Photoionization Front Experiments (abstract)

Yangyuxin Zou, Kasper Moczulski and Petros Tzeferacos
FLASH Simulations of Laser-Driven Laboratory Astrophysics Experiments to Study Jets in Common-Envelope Evolution of Binary Stars (abstract)

Wednesday, May 22nd

View this program: with abstracts session overview talk overview

06:45-08:00 Session 15: Breakfast

LOCATION: Shula Grill Restaurant

08:00-08:05 Session 16: Announcements

CHAIR: Local Organizing Committee
LOCATION: Horizon Grand Ballroom

08:05-09:40 Session 17: Jets

CHAIR: Hye-Sook Park
LOCATION: Horizon Grand Ballroom

08:05 Patrick Hartigan
Webb Telescope Images and Spectral Data Cubes of Irradiated Interfaces in the Orion Nebula and Shock Waves in Stellar Jets (abstract)

08:25 C. D. Arrowsmith, P. J. Bilbao, F. Miniati, P. Simon, A. F. A. Bott, S. Burger, H. Chen, F. D. Cruz, T. Davenne, A. Dyson, I. Efthymiopoulos, D. H. Froula, A. Goillot, J. T. Gudmundsson, D. Haberberger, J. Halliday, T. Hodge, B. T. Huffman, S. Iaquinta, B. Reville, S. Sarkar, A. A. Schekochihin, R. Simpson, V. Stergiou, R. M. G. M. Trines, T. Vieu, N. Charitonidis, L. O. Silva, R. Bingham and G. Gregori
Evidence of Suppressed Beam-Plasma Instabilities in a Laboratory Analogue of Blazar-Induced Pair Jets (abstract)
PRESENTER: P. J. Bilbao

08:45 Chikang Li, Gabriel Rigon, Christian Stoeckl, Niels Vanderloo, Timothy Johnson, Hui Li, Bruce Remington and Bruno Albertazzi
Exploring Astrophysical Relevant Plasma Jets on High-Energy-Density Laser Facilities (abstract)
PRESENTER: Chikang Li

09:05 Gabriel Rigon, Christian Stoeckl, Timothy M Johnson, Joseph Katz, Jonathan Peebles and Chikang Li
A Platform for Studies of Radiative Plasma Jets in the Presence of Magnetic Fields at OMEGA (abstract)
PRESENTER: Gabriel Rigon

09:25 Marin Fontaine, Clotilde Busschaert, Bruno Albertazzi, Michel Koenig and Emeric Falize
Experimental and Numerical Studies of Compressions of Dense Clouds Induced by Herbig-Haro Stellar Jets (abstract)
PRESENTER: Marin Fontaine

09:40-10:10 Coffee Break

10:10-11:40 Session 18: High Power Lasers

CHAIR: Farhat Beg
LOCATION: Horizon Grand Ballroom

10:10 Julien Fuchs
Generation of Faster Magnetized Shocks to Investigate Drift-Shock Particle Acceleration in the Laboratory (abstract)

10:30 Brandon K. Russell, Paul T. Campbell, Qian Qian, Jason A. Cardarelli, Christopher Arran, Thomas G. Blackburn, Stepan S. Bulanov, Sergei V. Bulanov, Gabriele M. Grittani, Stuart P.D. Mangles, Christopher P. Ridgers, Daniel Seipt, Louise Willingale and Alexander G.R. Thomas
Prospects for Laboratory Astrophysics at Multi-Petawatt Laser Facilities (abstract)
PRESENTER: Brandon K. Russell

10:50 Akira Mizuta, Shutaro Kurochi, Kentaro Sakai, Naofumi Ohnishi, Chun-Sung Jao, Yen-Chen Chen, Yao-Li Liu, Takeo Hoshi, Yuma Terachi, Akito Nakano and Yasuhiro Kuramitsu
Numerical Analysis of the Evolution of Kelvin Helmholtz Instabilities and Vortices Generation Associated with Collisionless Shock Experiments (abstract)
PRESENTER: Akira Mizuta

11:10 Luca Orusa, Damiano Caprioli, Anatoly Spitkovsky and Lorenzo Sironi
Particle Acceleration in 3D Simulations of Quasi-Perpendicular Shocks (abstract)
PRESENTER: Luca Orusa

11:22 Kirill Lezhnin, Samuel Totorica and Will Fox
PIC Simulations of Expanding HED Plasmas with Laser Ray Tracing (abstract)
PRESENTER: Kirill Lezhnin

12:00-13:30 Lunch Break

13:30-15:00 Session 19: Transport Properties and Spectroscopy

CHAIR: Tobias Dornheim
LOCATION: Horizon Grand Ballroom

13:30 Sam Vinko
Resonant Inelastic X-Ray Scattering in Warm-Dense Fe Compounds (abstract)

13:50 Cameron Allen, Matthew Oliver, Dirk Gericke, Laurent Divol, Gregory Kemp, Otto Landen, Landon Morrison, Yuan Ping, Markus Schoelmerich, Sarah Shores, Wolfgang Theobald, Tilo Doeppner and Thomas White
Experimentally Measuring Thermal Conductivity in Warm Dense Matter (abstract)
PRESENTER: Cameron Allen

14:10 Nitish Acharya, Hadley Pantell, Danae Polsin, Ryan Rygg, Gilbert Collins, Peter Celliers, Hussein Aluie and Jessica Shang
Measuring Viscosity at High Pressures and Temperatures Using Shock-Wave Perturbation Decay (abstract)
PRESENTER: Nitish Acharya

14:30 Travis Griffin, Daniel Haden, Thomas White, Bob Nagler, Hae Ja Lee, Eric Galtier, Dimitri Khaghani, Sameen Yunus, Eric Cunningham, Jerome Hastings, Jacob Molina, Siegfried Glenzer, Emma McBride, Luke Fletcher, Giulio Monaco, Ulf Zastrau, Karen Appel, Sebastian

Goede, Lennart Wollenweber, Dirk Gericke, Gianluca Gregori, Ben Armentrout, Carson Convery and Adrien Descamp
Validation of Electronic Bond Hardening in Thin Gold Films (abstract)
PRESENTER: Travis Griffin

14:42 Kelin Kurzer-Ogul, Brian Haines, David Montgomery, Silvia Pandolfi, Andrew Leong, Arianna Gleason, Hussein Aluie and Jessica Shang
Transport Properties in HED Shock-Bubble Interactions (abstract)
PRESENTER: Kelin Kurzer-Ogul

15:00-15:30 Coffee Break

15:30-17:00 Session 20: High Power Laser Experiments and Turbulence

CHAIR: Julien Fuchs
LOCATION: Horizon Grand Ballroom

15:30 Mamiko Nishiuchi, Chang Liu, Masayasu Hata, Nicholas Peter Dover, Kotaro Kondo, Akira Kon, Hironao Sakaki, Hiromitsu Kiriyama, James Kevin Koga, Tatsuhiko Miyatake, Haruya Matsumoto, Nuo Xu, Ginevra Casati, Zulfikar Najmudin, Marvin Paul Umlandt, Milenko Vescovi-Pinochet, Pengjie Wang, Tim Ziegler, Ulrich Schramm, Karl Zeil, Natsumi Iwata and Yasuhiko Sentoku
Dynamics of Plasma Formation and Highly Charged Au Ion Acceleration Driven by High-Intensity, High-Contrast Laser Pulse (abstract)
PRESENTER: Mamiko Nishiuchi

15:50 Gerrit Bruhaug, Ellie Tubman, Matthew Selwood, Matthew Freeman, Christopher Walsh, Hans Rinderknecht, James Rygg, Gilbert Collins and Jessica Shaw
Relativistic Electron Radiography of Laser Driven Foils (abstract)
PRESENTER: Gerrit Bruhaug

16:10 Daisuke Tanaka, Hiroshi Sawada, Koki Kawasaki, Toshihiro Somekawa, Toshinori Yabuuchi, Kohei Miyanishi, Keiichi Sueda, Yuichi Inubushi, Tomohiro Shimizu, Shoso Shingubara, Kohei Yamanoi and Keisuke Shigemori
Study on Energy Transport in Laser-Irradiated Nanowire Arrays for Creating Ultra-High Energy Density States with X-Ray Free Electron Laser, SACLA (abstract)
PRESENTER: Daisuke Tanaka

16:22 Kentaro Sakai, Kosuke Himeno, Kiyochika Kuramoto, Shuta Tanaka, Tatiana Pikuz, Takafumi Asai, Yuki Abe, Takumi Minami, Fuka Nikaido, Toshiharu Yasui, Hideki Kohri, Masato Kanasaki, Reona Ozaki, Keita Toyonaga, Hajime Maekawa, Hiromitsu Kiriyama, Akira Kon, Kotaro Kondo, Nobuhiko Nakanii, Wei-Yen Woon, Che-Men Chu, Kuan-Ting Wu, Chun-Sung Jao, Yao-Li Liu, Shogo Isayama, Atsushi Tokiyasu, Harihara Sudhan Kumar, Kentaro Tomita, Yuji Fukuda and Yasuhiro Kuramitsu
Plasma Structure and Magnetic Field Measurements with Scattered Intense Laser Beam (abstract)
PRESENTER: Kentaro Sakai

16:34 Seth Davidovits, David C. Collins, Saee Dhawalikar, Christoph Federrath, Luz Jimenez Vela, Mario Manuel and Sabrina R. Nagel
NIF Experiments on the Driving Parameter of Shock-Forced Turbulence for Star Formation (abstract)
PRESENTER: Seth Davidovits

19:00-21:00 Banquet Dinner

LOCATION: Horizon Grand Ballroom

19:45-20:30 Session 21: Banquet Dinner Speech

banquet talk

LOCATION: Horizon Grand Ballroom

19:45 Daniel Casey
ICF, Rampant Instabilities at >500 Gbar, and yet It Burns

Thursday, May 23rd

View this program: with abstracts session overview talk overview

06:45-08:00 Session 22: Breakfast

LOCATION: Shula Grill Restaurant

08:00-08:05 Session 23: Announcements

CHAIR: Local Organizing Committee
LOCATION: Horizon Grand Ballroom

08:05-09:40 Session 24: MHD Instabilities and Reconnection

CHAIR: Mikhail Medvedev
LOCATION: Horizon Grand Ballroom

08:05 Hantao Ji, Lan Gao, Geoff Pomraning, Kentaro Sakai and Fan Guo
Study of Electron Acceleration and Ion Acoustic Waves During Low-Beta Magnetic Reconnection Using Laser-Powered Capacitor Coils (abstract)
PRESENTER: Hantao Ji

08:25 Jacob Pearcy, Michael Rosenberg, Timothy Johnson, Graeme Sutcliffe, Benjamin Reichelt, Jack Hare, Nuno Loureiro, Richard Petrasso and Chikang Li

Experimental Evidence of Plasmoids in High-β Magnetic Reconnection (abstract)
PRESENTER: *Jacob Pearcy*

08:45 *Yasuhiro Kuramitsu*, *Kentaro Sakai*, *Toseo Moritaka*, *Taiki Jikei*, *Takanobu Amano*, *Yosuke Matsumoto*, *Chun-Sung Jao*, *Yen-Chen Chen*, *Fuka Nikaido*, *Yao-Li Liu*, *Takumi Minami*, *Shogo Isayama*, *Yuki Abe*, *Naofumi Ohnishi*, *Akira Mizuta*, *Yuma Terachi*, *Akito Nakano*, *Takeo Hoshi*, *Naoya Tamaki*, *Shutaro Kurochi*, *Che-Men Chu*, *Wei-Yen Woon*, *Masato Kanasaki*, *Satoshi Kodaira*, *Yuji Fukuda*, *Bruno Albertazzi* and *Michel Koenig*
Magnetic Reconnections Driven by Electron Dynamics in the Presence of a Weak External Magnetic Field (abstract)
PRESENTER: *Yasuhiro Kuramitsu*

09:05 *V. Valenzuela-Villaseca*, *M. Bailly-Grandvaux*, *E. G. Blackman*, *J. P. Chittenden*, *F. Ebrahimi*, *W. Fox*, *J. Goodman*, *J. Griff-McMahon*, *J. W. D. Halliday*, *J. D. Hare*, *H. Ji*, *M. E. Koepke*, *S. V. Lebedev*, *S. Malko*, *S. Merlini*, *D. R. Russell*, *D. B. Schaeffer*, *L. G. Suttle*, *F. Suzuki-Vidal*, *G. F. Swadling*, *E. R. Tubman*, *C. A. Walsh* and *V. Zhang*
Progress Towards Laboratory Modelling of Magnetized Accretion Disks and Plasma Jets Using Intense Laser and Pulsed-Power Generators (abstract)
PRESENTER: *V. Valenzuela-Villaseca*

09:25 *Taiki Jikei*, *Takanobu Amano*, *Yosuke Matsumoto* and *Yasuhiro Kuramitsu*
Magnetic Amplification by the Weibel Instability in Weakly Magnetized Astrophysical Shocks and Laboratory Laser Experiments (abstract)
PRESENTER: *Taiki Jikei*

09:40-10:10 Coffee Break

10:10-11:50 Session 25: Turbulence and Magnetized Shocks

CHAIR: *Hantao Ji*
LOCATION: Horizon Grand Ballroom

10:10 *Petros Tzeferacos*, *Archie Bott*, *Hannah Poole*, *Charlotte Palmer*, *Kasper Moczulski*, *Anthony Scopatz*, *Dustin Froula*, *Charles Heaton*, *Joseph Katz*, *Chikang Li*, *Nicolas Lopez*, *Hye-Sook Park*, *Patrick Reichherzer*, *Yangyuxin Zou*, *Adam Reyes*, *Steven Ross*, *Alexander Schekochihin*, *Donald Lamb* and *Gianluca Gregori*
Laboratory Evidence of Fluctuation Dynamo in Supersonic Turbulence (abstract)
PRESENTER: *Petros Tzeferacos*

10:30 *Archie Bott*, *Hannah Poole*, *Charlotte Palmer*, *Charles Heaton*, *Patrick Reichherzer*, *Nicholas Lopez*, *Kasper Moczulski*, *Dustin Froula*, *Tim Johnson*, *Joseph Katz*, *Chikang Li*, *Hye-Sook Park*, *Richard Petrasso*, *Brian Reville*, *Adam Reyes*, *J. Steven Ross*, *Dongsu Ryu*, *Anthony Scopatz*, *Fredrick Séguin*, *Thomas White*, *Alexander Schekochihin*, *Donald Lamb*, *Petros Tzeferacos* and *Gianluca Gregori*
'Dynamo Interrupted at Its Action': Decaying Magnetic Fields in Turbulent Laser-Plasmas (abstract)
PRESENTER: *Archie Bott*

10:50 *Derek Schaeffer*, *Victor Zhang*, *Margaux Francois*, *Philip Moloney*, *Peter Heuer*, *Katherine Chandler*, *Gennady Fiksel*, *Damiano Caprioli*, *Jeremy Chittenden*, *Emmanuel D'Humieres*, *Will Fox*, *Jack Hare*, *Frances Kraus*, *Carolyn Kuranz*, *Sergey Lebedev*, *Chuang Ren*, *Xavier Ribeyre*, *Danny Russell* and *Jonathan Davies*
Magnetized Collisionless Shocks on HED Facilities (abstract)
PRESENTER: *Derek Schaeffer*

11:10 *Yuyao Wang*, *Luca Antonelli*, *Nathan Joiner*, *Francisco Suzuki-Vidal*, *Tim Ringrose* and *Nigel Woolsey*
Laboratory Insights into Shock-Driven Turbulent Mixing (abstract)
PRESENTER: *Yuyao Wang*

11:22 *Yu Zhang*, *Peter Heuer*, *Chuang Ren*, *Jonathan Davies*, *Han Wen*, *Fernando García-Rubio* and *Derek Schaeffer*
Particle Acceleration and Ion-Electron Energy Exchange in Quasi-Parallel Magnetized Collisionless Shocks (abstract)
PRESENTER: *Yu Zhang*

11:34 *Thomas Vincent*, *Archie Bott*, *Gianluca Gregori* and *Petros Tzeferacos*
Design of Experiments on the Orion Laser to Measure Thermal Transport in High-β, Weakly Collisional Plasma (abstract)
PRESENTER: *Thomas Vincent*

12:00-13:30 Lunch Break

13:30-15:15 Session 26: Opacity & Radiation

CHAIR: *Sam Vinko*
LOCATION: Horizon Grand Ballroom

13:30 *David Hoarty*, *John Morton* and *Jonathan Rougier*
Radiation Burn-Through Measurements to Infer Opacity at Conditions Close to the Solar Radiative Zone - Convective Zone Boundary. (abstract)
PRESENTER: *David Hoarty*

13:50 *Guillaume Loisel*
Time-Resolved Spectroscopy to Advance Stellar Opacity Efforts on Z (abstract)

14:10 *James Bailey*, *Guillaume Loisel*, *Taisuke Nagayama*, *Dan Mayes*, *Greg Dunham* and *Stephanie Hansen*
Progress in Understanding Stellar Interior Opacity with Laboratory Experiments at Z (abstract)

PRESENTER: James Bailey

14:22 Roberto Mancini, Jeffrey Rowland, Robert Heeter, Richard London, Kathy Opachich, Howard Scott and Sean Regan
The Challenge of Producing Laboratory Photoionized Plasmas in Steady State (abstract)
PRESENTER: Roberto Mancini

14:42 Michael Springstead, H LeFevre, K Kelso, T Nagayama, G Loisel, J Bailey, S Klein, G Jaar, K Swanson, B Dunlap, P Cho, D Mayes, R Mancini, D Winget, J Davis, W Gray, R Drake and C Kuranz
Laboratory Generated Photoionization Fronts Relevant to Astrophysics (abstract)
PRESENTER: Michael Springstead

15:02 Victor Tranchant, Fernando Garcia Rubio, Eddie Hansen and Petros Tzeferacos
Studying Radiation Effects in Shocks and the Rayleigh-Taylor Instability with FLASH (abstract)
PRESENTER: Victor Tranchant

15:15-15:45 Coffee Break

15:45-17:05 Session 27: Materials at High Pressures III

CHAIR: Amy Jenei
LOCATION: Horizon Grand Ballroom

15:45 Michelle Marshall, Donghoon Kim, Danae Polsin, Ian Ocampo, Ryan Rygg, Tom Duffy, Terry-Ann Suer, Ray Smith, Jon Eggert, Andrew Krygier, Shuai Zhang and Rip Collins
High-Pressure Phase Transformations in Ramp-Compressed SiO2 (abstract)
PRESENTER: Michelle Marshall

16:05 June Wicks
Phase Diagram Models of Matter and the Kinetics of Phase Transitions at Extreme Conditions (abstract)

16:25 Xuchen Gong, Danae Polsin, Reetam Paul, Brian Henderson, Michelle Marshall, Mary Kate Ginnane, Jon Eggert, Raymond Smith, Federica Coppari, J. Ryan Rygg and Gilbert W. Collins
High Pressure Phase Diagram of Silicon (abstract)
PRESENTER: Xuchen Gong

16:45 Hannah Poole, Mary Kate Ginnane, Marius Millot, Gilbert Collins, Suxing Hu, Danae Polsin, Tom White, David Chapman, Ryan Rygg, Sean Regan and Gianluca Gregori
Multi-Messenger Measurements of the Static Structure of Shock-Compressed Liquid Silicon at 100 GPa (abstract)
PRESENTER: Hannah Poole

Friday, May 24th

View this program: with abstracts session overview talk overview

06:45-08:00 Session 28: Breakfast

LOCATION: Shula Grill Restaurant

08:00-08:05 Session 29: Announcements

CHAIR: Local Organizing Committee
LOCATION: Horizon Grand Ballroom

08:05-09:35 Session 30: Hydrodynamic Instabilities

CHAIR: Petros Tzeferacos
LOCATION: Horizon Grand Ballroom

08:05 Hong Sio, Victorien Bouffetier, Gabriel Pérez-Callejo, Luke Ceurvorst, Jonathan Peebles, Petros Tzeferacos, Vladimir Smalyuk, Omar Hurricane and Alexis Casner
Laboratory Investigations of Magnetized Kelvin-Helmholtz Instability on NIF and OMEGA (abstract)
PRESENTER: Hong Sio

08:25 Forrest W. Doss, D. A. Yager-Elorriaga, P. F. Knapp, G. A. Shipley, E. C. Merritt, C. Jennings, M. R. Martin, D. E. Ruiz, A. J. Porwitzky, S. W. Cordaro, L. Shulenburger and T. R. Mattsson
Investigating Richtmyer-Meshkov Instabilities at High Energy Densities on the Z Machine (abstract)
PRESENTER: Forrest W. Doss

08:37 Michael Wadas, Heath LeFevre, Loc Khieu, Griffin Cearley, Carolyn Kuranz and Eric Johnsen
Scaling of Vortex Rings Ejected from Shocked Interfaces (abstract)
PRESENTER: Michael Wadas

08:57 Riccardo Bonazza
Scaling of Shock-Driven Flows over Two Orders of Magnitude in Length Scales Between Shock Tube and NIF Environments (abstract)

09:17 E. C. Merritt, F. W. Doss, C. A. Di Stefano, R. Sacks, A. M. Rasmus, J. M. Levesque, K. A. Flippo, H. F. Robey, D. W. Schmidt, N. S. Christiansen, M. Millot, L. Kot, T. S. Perry and D. D. Meyerhofer
First Observations of Distinct RM Growth Scenarios for Successively Shocked Interfaces (abstract)
PRESENTER: E. C. Merritt

09:35-10:05 Coffee Break

10:05-11:30 Session 31: Materials at High Pressures IV

CHAIR: *Tilo Doeppner*

LOCATION: Horizon Grand Ballroom

10:05 *Gaia Righi*, *Yong-Jae Kim*, *Thomas Lockard*, *Matthew Hill*, *James McNaney*, *Robert Rudd* and *Hye-Sook Park*

Design of Laser-Driven High-Pressure Iron Rayleigh–Taylor Strength Experiments (abstract)

PRESENTER: *Gaia Righi*

10:25 *Yong-Jae Kim*, *Gaia Righi*, *Orlando Deluigi*, *Robert Rudd*, *Bruce Remington*, *Carlos Ruestes*, *Camelia Stan*, *Christopher Wehrenberg*, *Marc Meyers*, *Eduardo Bringa*, *Arianna Gleason* and *Hye-Sook Park*

Laser-Driven Rayleigh-Taylor Strength Measurements of Iron (abstract)

PRESENTER: *Yong-Jae Kim*

10:45 *Amy Lazicki*, *Martin Gorman*, *Sabri Elatresh*, *Marc Cormier*, *Stanimir Bonev*, *David McGonegle*, *Richard Briggs*, *James Ryan Rygg*, *Amy Coleman*, *Stephen Rothman*, *Lisa Peacock*, *Joel Bernier*, *Federica Coppari*, *David Braun*, *Dayne Fratanduono*, *Roald Hoffman*, *Gilbert Collins*, *Justin Wark*, *Raymond Smith*, *Jon Eggert* and *Malcolm McMahon*

Experimental Observation of Open Structures in Elemental Magnesium at Terapascal Pressures (abstract)

PRESENTER: *Amy Lazicki*

11:05 *Andrew Krygier*, *Hong Sio*, *Stan Stoupin*, *Rob Rudd*, *Stanimir Bonev*, *Dave Braun*, *Federica Coppari*, *Amy Coleman*, *Jon Eggert*, *Amy Jenei*, *Bernie Kozioziemski*, *Ryan Rygg*, *James McNaney* and *Yuan Ping*

Temperature Determination in Multi-Mbar Pressure Solids with Extended X-Ray Absorption Fine Structure at the National Ignition Facility (abstract)

PRESENTER: *Andrew Krygier*

PROGRAM FOR MONDAY, MAY 20TH

Days: previous day next day all days

View: session overview talk overview

06:45-08:00 Session 2: Breakfast

LOCATION: Shula Grill Restaurant

08:00-08:05 Session 3: Announcements

CHAIR: *Local Organizing Committee*
LOCATION: Horizon Grand Ballroom

08:05-08:35 Session 4: Perspectives and Insights

CHAIR: *Tomasz Plewa*
LOCATION: Horizon Grand Ballroom

08:05 *R. Paul Drake*
The History and Value of HEDLA

08:20 *Bruce Remington*
HEDLA at the Extreme

08:35-10:00 Session 5: Materials at High Pressures I

CHAIR: *Ryan Rygg*
LOCATION: Horizon Grand Ballroom

08:35 *Dominik Kraus*
Light Elements at Mbar to Gbar Pressures

ABSTRACT. I will discuss recent experiments at high energy laser systems to mimic planetary and stellar interiors in the lab. Via nanosecond dynamic compression in combination with XFEL probing, we can access exotic chemistry and the formation of unusual structures. With shorter pulses giving higher intensities and using spectrally resolved X-ray scattering, we can probe matter at conditions similar to the envelopes of white dwarfs. Experiments at the National Ignition Facility finally provide access to the deep interiors of small stars. X-ray scattering and absorption measurements give unprecedented insights into these peculiar states of matter.

08:55 *Ivan Oleynik*
Extreme Metastability of Diamond and Its Transformation to BC8 Post-Diamond Phase of Carbon

ABSTRACT. Diamond possesses exceptional physical properties due to its remarkably strong carbon-carbon bonding, leading to significant resilience to structural transformations at very high pressures and temperatures. Very recently, a substantial effort has been directed to investigate carbon at megabar pressures and thousands of Kelvins to provide data for developing models of planetary interiors for carbon-rich exoplanets as well as to optimize diamond capsules for inertial confinement fusion experiments. Despite several experimental attempts, synthesis and recovery of the theoretically predicted post-diamond BC8 phase remains elusive. Through quantum accurate, multi-million atom molecular dynamics (MD) simulations, we have uncovered the extreme metastability of diamond at very high pressures, significantly exceeding its range of thermodynamic stability. We predict the post-diamond BC8 phase to be experimentally accessible only within a narrow high pressure-temperature region of the carbon phase diagram. The diamond to BC8 transformation proceeds through pre-melting followed by BC8 nucleation and growth in the metastable carbon liquid. We design a double-shock compression pathway to achieve BC8 synthesis, which is currently being explored in theory-inspired Discovery Science experiments at National Ignition Facility.

09:15 *Mungo Frost*, *R Stewart McWilliams*, *Siegfried Glenzer* and *Alexander Goncharov*
Diamond Precipitation Dynamics from Hydrocarbons at Icy Planet Interior Conditions
PRESENTER: *Mungo Frost*

ABSTRACT. The mantles of icy planets are composed of ices formed for a variety of small molecules, including water, ammonia and methane. Under the extreme conditions found within these bodies, the methane converts to more complex hydrocarbons and ultimately the carbon precipitates as diamond. The pressure, and hence planetary depth, at which this process occurs has implication for their internal processes, including internal heating, convection and potentially magnetic field generation. There is substantial disagreement between statically compressed laser heated diamond anvil cells (DACs) and laser driven dynamic compression studies on the conditions of diamond formation from hydrocarbons. Recent results from X-ray pump-probe experiments on DAC compressed hydrocarbons at the European X-ray Free Electron Laser reveal the origin of these discrepancies to be kinetic and shed light on the carbon-hydrogen demixing process.

09:35 Martin Preising, Martin French, Christopher Mankovich, François Soubiran and Ronald Redmer
Material Properties of Saturn'S Interior from Ab Initio Simulations
PRESENTER: Martin Preising

ABSTRACT. Calculation of material properties from ab inito simulations along Jupiter [1] and Brown Dwarf adiabats [2] have been subject of earlier studies. However, accurate models of Saturn's interior are still very challenging. A recent study by Mankovich and Fortney on Jupiter and Saturn models was based on a single physical model [3] which predicts a strongly differentiated helium distribution in Saturn's deep interior, resulting in a helium-rich shell above a diffuse core.

We focus on the calculation of material properties of matter at P-T conditions along the Saturn model proposed by Mankovich and Fortney [4]. The dissociation of hydrogen as well as the onset of the helium-rich layer have profound impact on material properties: Dissociation of hydrogen triggers the metallization of the hydrogen sub-system and the band gap of the system closes. However, helium is still an insulator under all the conditions of the model [5,6]. The onset of the helium-rich layer in the deep interior therefore again changes the properties of the mixture: Molecular hydrogen dominates the outer atmosphere, followed by a layer of mainly metallic hydrogen in the interior, followed again by a layer of helium-dominated insulating material above the core. We present results on thermodynamic and transport properties of a hydrogen-helium-water mixture that closely resembles the element distribution of the Saturn model. We discuss implications of the results on our understanding of Saturn's interior and evolution.

[1] French et al., Astrophys. J. Suppl. Ser., 202, 5 (2012). [2] Becker et al., Astron. J., 156, 149 (2018). [3] Mankovich and Fortney, Astrophys. J., 889, 51 (2020). [4] Preising et al., Astrophys. J. Suppl. Ser., 269, 47 (2023). [5] Monserrat et al., Phys. Rev. Lett., 112, 055504 (2014). [6] Preising and Redmer, Phys. Rev. B, 102, 224107 (2020).

10:00-10:30 Coffee Break

10:30-12:00 Session 6: Supernovae, Hydrodynamic Instabilities, and Shocks

CHAIR: Alexander Velikovich
LOCATION: Horizon Grand Ballroom

10:30 Bruce Remington
New Regimes of Frontier Science on the National Ignition Facility

ABSTRACT. Highlights from research done on the National Ignition Facility (NIF) laser through the Discovery Science program will be presented. Plasma nuclear reactions relevant to stellar nucleosynthesis and nuclear reactions in high energy astrophysical scenarios are being studied. [1] Equations of state (EOS) at very high pressures (0.1-100 TPa or 1-1000 Mbar) relevant to planetary cores, brown dwarf interiors, and white dwarf envelopes are being measured on NIF, and show that the level of ionization can significantly affect the compressibility of the sample. [2-6] Studies of Rayleigh-Taylor instabilities in planar and cylindrical geometries at high Reynolds number, relevant to supernovae explosions and ICF implosions, are being investigated. [7-12] Relativistically hot plasmas [13,14] and target-normal sheath acceleration (TNSA) of protons [15-17] are also being studied on the NIF ARC laser. Experiments to study magnetic reconnection at high energy densities are underway. [18] High velocity, low density interpenetrating plasmas that generate collisionless astrophysical shocks, magnetic fields, bursts of neutrons, and that accelerate particles relevant to cosmic ray generation are also being studied on NIF. [19-21] And NIF experiments have demonstrated strong suppression of heat conduction in a laboratory replica of galaxy-cluster turbulent plasmas. [22] A selection from these results will be presented and a path forward suggested.

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10:42 Tomasz Plewa, Andrey Zhiglo, Ezra Brooker, Brandon Gusto and Ryan Learn
Thermonuclear Turbulent Combustion in Type Ia Supernovae
PRESENTER: Tomasz Plewa

ABSTRACT. We discuss the results of computer simulations of reactive turbulence for conditions expected to exist in outer layers of massive white dwarfs during advanced stages of their evolution. We consider a scenario in which a weakly compressible turbulence in an

initially quiescent, low-density, self-heated plasma is driven on large scales presumably by an approaching, Rayleigh-Taylor-unstable flame front.

We probe a parameter space of this problem by obtaining a series of models systematically varying characteristics of turbulence, and in magnetized models, also the initial strength of the magnetic field. The ultimate outcome of our models is a deflagration-to-detonation transition (DDT) due to the Zel'dovich reactivity gradient mechanism [1]. For the mechanism to be viable in the context of powering Type Ia supernova explosions, a DDT delay time must be sufficiently short compared to the SN Ia explosion timescale. The two critical problem parameters controlling the DDT delay time is the fuel ignition time and compressibility of turbulence. The delay time decreases with the ignition time, as expected, and, for a given turbulence Mach number, somewhat counterintuitively, with the compressibility of turbulence. We also find some initial evidence of magnetic field participating in the DDT preconditioning process.

Because DDT-relevant scales are orders of magnitude smaller than numerical resolution of current SN Ia explosions models, we are developing a suitable DDT subgrid scale model (SGS). We use a data-driven approach in which a Zel'dovich DDT condition, as described by the Khokhlov inequality [2], is parameterized in terms of turbulence fluctuations using a neural network. We briefly discuss a process of constructing a one-dimensional version of our ML-based DDT SGS, and its ability to correctly identify DDT in numerical simulations of SN Ia explosions.

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[2] A. M. Khokhlov. Mechanisms for the initiation of detonations in the degenerate matter of supernovae. Astronomy and Astrophysics, 246(2):383–396, 1991.

11:02 *Carolyn Kuranz*, *Heath LeFevre*, *Matthew Trantham*, *Eric Johnsen*, *Griffin Cearly*, *Kevin Ma*, *Hye-Sook Park*, *Michael MacDonald*, *Marius Millot* and *Tilo Doeppner*
Creating Astrophysically Relevant Systems in the Laboratory in the High-Energy-Density Regime
PRESENTER: *Carolyn Kuranz*

ABSTRACT. Laboratory astrophysics can provide insight into some astrophysical objects or processes, which are often observed from great distances under uncontrolled and unknown conditions. For an experiment to be well-scaled to an astrophysical process, several specific conditions must be considered, including key governing equations, specific spatial and temporal scaling, and global dynamics. In some cases, these conditions can be met using high-energy-density experimental facilities, such as, high-energy lasers or pulsed power devices. Experiments conducted at the National Ignition Facility are relevant to SN1993J, a red supergiant, core-collapse supernova. We focused on the Rayleigh-Taylor instable interface between the forward and reverse shocks in SN1933J. Here the forward shock is moving into the low-density circumstellar medium and is highly radiative. In the scaled experiments, a hohlraum drive creates a blast wave structure in a mm-scale target with a decrease in density at a perturbed interface. After the blast wave moves into the lower density material, the perturbation with grow due to hydrodynamics instabilities and the shock becomes radiative. We have detected the evolution of the interface structure under these conditions and will show the resulting experimental and radiation hydrodynamics simulation data. We found that significant energy fluxes from radiation and thermal heat conduction affect the hydrodynamics growth at the interface. Such effects are not currently included in astrophysical models but will have significant effects on the interface structure. We compare our experimental results with radiation hydrodynamics simulations and theoretical radiative shock models .

11:22 *Mateusz Ruszkowski*
Impact of Cosmic Rays on Galaxy Evolution

ABSTRACT. The nature of stellar feedback mechanisms (i.e., injection of energy and momentum into the interstellar medium by exploding supernovae) is one of the key outstanding challenges in the galaxy formation field. Recent advances in the field of astrophysical feedback strongly suggest that cosmic rays (CRs) — high-energy ions produced, e.g., in supernova shocks — may be crucially important for our understanding of cosmological galaxy formation and evolution. The appealing features of CRs are their relatively long cooling times, relatively strong dynamical coupling to plasma, and energy density comparable to that in turbulent motions and magnetic fields. CRs may, therefore, play an essential role in controlling feedback and driving galactic-scale outflows. However, the strength of CR feedback depends very sensitively on the dynamical coupling of CRs to the plasma, i.e., on CR transport mechanisms. I will briefly discuss forward modeling efforts to explain the intensity profiles, multiwavelength spectra, and synchrotron polarization observations of galactic-scale winds using simulations that incorporate CR physics including transport processes. A complete understanding of CR transport will require significant advancements in plasma physics, testing models against astronomical observations, and laboratory astrophysics experiments. I will present a brief overview of the state-of-the-art of CR feedback field emphasizing fundamental results and highlighting key outstanding challenges.

11:42 *Arno Vanthieghem*, *Vassilis Tsiolis*, *Anatoly Spitkovsky*, *Yasushi Todo*, *Kazuhiro Sekiguchi* and *Frederico Fiuza*

The Electron-Ion Temperature Ratio: from Newtonian to Relativistic Weakly Magnetized Shock Waves
PRESENTER: Arno Vanthieghem

ABSTRACT. Weakly magnetized shock waves are paramount to a large diversity of environments, including supernova remnants, blazars, and binary-neutron-star mergers. Understanding the distribution of energy between electrons and ions within these astrophysical shock waves spanning a wide spectrum of velocities is a long-standing challenge. In this study, we present a unified model for the downstream electron temperature within unmagnetized shock waves, encompassing velocities from Newtonian to extreme relativistic regimes. Heating results from an ambipolar electric field generated by the difference in inertia between electrons and ions, coupled with rapid electron scattering in the decelerating turbulence. Based on large-scale Particle-In-Cell simulations supporting analytical models, our findings demonstrate that the electron temperature consistently represents 10% of the incoming ion kinetic energy in the shock front frame.

12:00-13:30 Lunch Break

13:30-15:10 Session 7: Collisionless Shocks

CHAIR: Carolyn Kuranz
LOCATION: Horizon Grand Ballroom

13:30 Hye-Sook Park, E. Tubman, F. Fiuza, C. Bruulsema, D. Higginson, D. Larson, M. Manuel, K. Moczulski, M. Pokornik, B. Pollock, D. Ryutov, G. Swadling and P. Tzeferacos
Study of Astrophysical Collisionless Shocks in the Laboratory
PRESENTER: Hye-Sook Park

ABSTRACT. High Mach number astrophysical plasmas can create collisionless shocks via plasma instabilities and turbulence that are responsible for magnetic field generations and cosmic ray acceleration. With the advent of high-power lasers, laboratory experiments with high-Mach number, collisionless plasma flows can provide critical information to help understand the mechanisms of shock formation by plasma instabilities and self-generated magnetic fields. A series of experiments were conducted on Omega and the National Ignition Facility to observe: the filamentary Weibel instability that seeds microscale magnetic fields [1, 2]; collisionless shock formation seen by an abrupt ~4x increase in density and ~6x increase in temperature; and electron acceleration distributions that deviated from the thermal distributions [3]. In addition to the case of collisionless shock formation under unmagnetized initial condition, shock formation under magnetized environment is also being studied [4]. Experimental results along with theoretical interpretations aided by particle-in-cell simulations will be discussed.

[1] H.-S. Park et al., HEDP 8, 38 (2012) [2] C. Huntington et al., Nature Physics 11, 173 (2015) [3] F. Fiuza et al., Nature Physics, 16, 916 (2020) [4] E. Tubman et al., in preparation (2024)

* This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

13:50 George Swadling
From Microscale Physics to Astrophysical-Scale Effects: Using Experiments on Omega and the NIF to Unravel the Enduring Enigma of Astrophysical Collisionless Shocks

ABSTRACT. High Mach number shocks are ubiquitous in astrophysics. At the low densities typical of astrophysical plasmas, ion-ion collisional mean free path lengths are often larger than the observed shock fronts. These shocks must therefore be "collisionless", mediated not by collisions but instead by electro-magnetic fields seeded and amplified through the growth of plasma instabilities. Magnetic fields seeded and amplified by these collisionless shocks are thought to play a key role in the acceleration of cosmic rays. We report on laboratory experiments using the Omega and NIF lasers to investigate the formation of high Mach number collisionless shocks between pairs of interpenetrating laser-generated plasma flows. Omega experiments diagnosed using proton radiography showed the formation, growth, and merger of the filamentary magnetic field structures associated with the Weibel instability in the collisionless regime [1]. Novel experiments using Thomson scattering allowed quantitative measurements to be made of current and magnetic field modulations [2]. Initial, higher-energy experiments using the NIF laser indicated enhanced heating of the interacting flows compared to that expected from PIC modelling, indicating the possible onset of collisionless shock formation [3]. In the most recent experiments, a significant enhancement of density and temperature was observed using the new NIF Thomson scattering diagnostic. This data, along with enhanced neutron and energetic electron emission, is consistent with the observation of a fully formed collisionless shock [4]. The most recent experiments have focused on determining the ratio of the ion and electron temperatures in the shocked plasma, revealing details of the ion kinetics in the shock.

* Prepared by LLNL under Contract DE-AC52-07NA27344.

[1] C. M. Huntington et al., Nature Physics, 11, 173 (2015). [2] G.F. Swadling et al., Phys. Rev. Lett. 124, 215001 (2020). [3] J. S. Ross et al., Phys. Rev. Lett., 118, 185003 (2017). [4] F. Fiuza et al., Nature Physics 16, 916–920 (2020).

14:10 *Eleanor Tubman*, *Hye-Sook Park*, *David Larson*, *Drew Higginson*, *Bradley Pollock*, *George Swadling*, *Colin Bruulsema*, *Brent Blue*, *Petros Tzeferacos*, *Kasper Moczulski*, *Michael Pokornik*, *Mario Manuel* and *Frederico Fiuza*

Measuring Reflected Ions in the Upstream of a Magnetised, Collisionless Shock.

PRESENTER: *Eleanor Tubman*

ABSTRACT. Magnetized, collisionless shocks are observed throughout the universe including within supernova remnants and at Earth's magnetopause. These shocks have the potential to accelerate particles to far greater energies than many other astrophysical processes and may provide a source of high-energy cosmic rays. One challenge, yet to be addressed, is determining the exact mechanism of the energy dissipation by these shock waves. Designing a laboratory-based experiment that can create and investigate these shocks is advantageous for testing different theories and developing our knowledge of this phenomena.

This talk will present results from a platform using the Omega laser facility. A gas jet and MIFED assembly provide a pre-ionized, pre-magnetized background plasma, through which a shock wave is launched. We diagnose the effect of the background magnetic fields on the shock formation using Thomson scattering. This allow us to measure the plasma conditions, as well as identify where the background and shock piston material are spatially located. In addition, we diagnose the evolving electromagnetic field structures using proton probing. These diagnostics have led to the clear identification of the shock's development stages as well as the initial separation of the shock piston and background material. The results assist in benchmarking particle-in-cell codes and hydrodynamic models as well as interpreting measurements from spacecrafts, to gain a better understanding of the underlying physics.

14:30 *Emeric Falize*, *Lea Dollerschell*, *Marin Fontaine*, *Christopher Bowen*, *Clotilde Busschaert*, *Nicolas Charpentier*, *Andrea Ciardi*, *Jean-Christophe Pain*, *Victor Tranchant* and *Lucile Van Box Som*

From Dimensional Analysis to Mapping Transformations: Scalability of Astrophysical Flows in Accretion-Explosion Environments

PRESENTER: *Emeric Falize*

ABSTRACT. Central to laboratory astrophysics is the investigation of similarity properties of astrophysical flows and the development of scaling laws that serve as a bridge between astrophysical and laboratory plasmas [1]. Cooling flows are common in astrophysical environments and now at laboratory scales [2]. In these environments, various instabilities can develop, such as the Chevalier-Imamura cooling instability [3] or Falle instability (Catastrophic cooling) [4], which underlie luminosity oscillations observed in different accreting binary stars [5,6]. We discuss the possibility of reproducing these radiation flows in the laboratory and focus on the limits of radiation hydrodynamical scaling laws with respect to microscopic physics. Recently, a new approach has been developed to generalize dimensional analysis: mapping theory. The results of this theoretical program open up new possibilities for reproducing radiation astrophysical flows. These transformations have been successfully applied to extreme X-ray bursts around neutron stars [7]. During these explosions, intense radiative supersonic waves are produced and propagate in the surrounding accretion disk. Through the new theoretical approach presented in this work, we demonstrate the possibility of replicating such phenomena in the laboratory using powerful lasers like the National Ignition Facility and the Laser MegaJoule.

[1] Ryutov et al., Astrophys. J., 518, 821 (1999) [2] Markwick et al., MNRAS (2024) [3] Chevalier & Imamura Astrophys. J., 261, 543 (1982) [4] Falle, MNRAS, 195, 1011 (1981) [5] Busschaert et al., Astronom. Astrophys., 579, A25 (2015) [6] Van Box Som et al., MNRAS, 473, 3158 (2018) [7] Tranchant et al., Astrophys. J., 936, 14 (2022)

14:42 *James Beattie*

The Compressible Turbulent Dynamo

ABSTRACT. Magnetic dynamos are a ubiquitous way of growing, maintaining and structuring magnetic fields across many scales in the Universe. Turbulent, or small-scale dynamos, which power the turbulent components of the velocity and magnetic field, provide the reservoir of magnetic energy for large-scale dynamos through the electromotive force. Turbulent dynamos have been largely studied both theoretically and numerically in the incompressible regime, which has only limited application in both astrophysics and in lab experiments, where there can be strong gas density fluctuations and shocked gas. In this talk I will highlight some of the latest results in compressible (and supersonic) turbulent dynamo numerical calculations and theory, highlighting both the similarities and differences that the supersonic turbulent dynamo has with the incompressible turbulent dynamo.

14:54 *Mikhail Medvedev*

Quasi-Nonlinear Approach to the Weibel Instability in the Upstream Medium of a Collisionless GRB Shock

ABSTRACT. Astrophysical plasmas, such as in collisionless shocks in gamma-ray bursts, and high-energy-density laboratory plasmas often have large-amplitude, sub-Larmor-scale electromagnetic fluctuations excited by various kinetic-streaming or anisotropy-driven instabilities. The Weibel (or the filamentation) instability is particularly important because it can rapidly generate strong magnetic fields, even in the absence of seed fields. Particles propagating in collisionless plasmas with such small-scale magnetic fields undergo stochastic deflections similar to Coulomb collisions, with the magnetic pitch-angle diffusion

coefficient representing the effective ``collision'' frequency. We show that this effect of the plasma ``quasi-collisionality'' can strongly affect the growth rate and evolution of the Weibel instability in the deeply nonlinear regime. This result is especially important for understanding cosmic-ray-driven turbulence in an upstream region of a collisionless shock of a gamma-ray burst or a supernova. We demonstrate that the quasi-collisions caused by the fields generated in the upstream suppress the instability slightly but do not shut it down completely.

15:10-15:40 Coffee Break

15:40-17:20 Session 8: Fusion & Particle Acceleration

CHAIR: *Mamiko Nishiuchi*
LOCATION: Horizon Grand Ballroom

15:40 *Daniel Casey*
Thermonuclear Reactions Probed at Stellar Core Conditions with Laser-Based Inertial Confinement Fusion*

ABSTRACT. Stellar models require accurate thermonuclear reaction rates to predict the nuclear power production and dynamic evolution of these systems. Direct measurement of nuclear reaction rates in thermonuclear plasmas is challenging because these conditions are difficult to produce and diagnose. Still, there are physics issues such as plasma electron-screening or other plasma-nuclear effects that are present in stellar cores but not in terrestrial accelerator experiments.

Laser-based inertial confinement fusion (ICF) implosions produce extremely dense, hot plasmas that provide a path to study reactions in these thermonuclear conditions. However, ICF experiments have significant challenges not found in accelerator experiments. For example, the complex temporal and spatial evolution of these systems can make absolute cross-section measurements difficult and quite challenging to model. In this talk, we show that these issues can be overcome and ICF implosions can be used to make nuclear measurements in some specific circumstances.

In particular, the method of yield ratios is used to infer 2H(d,n)3He and 3H(t,2n)4He astrophysical S-factors by observing the 2H(d,n)3He and 3H(t,2n)4He yields relative to 3H(d,n)4He, in gas-filled implosions, using the 3H(d,n)4He reactivity as a reference. The resulting data shows excellent agreement with evaluations and prior accelerator data bolstering confidence in this method.

This technique is now being explored as a candidate for a future plasma-electron-screening experiment to attempt to observe enhancements to reaction rates in the presence of plasma electrons. Ongoing work to that end, will be shown.

*This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL-ABS-768962

16:00 *Shinsuke Fujioka*, *Hiroki Matsubara*, *Yuga Karaki*, *Ryuya Yamada*, *Takumi Tsuido*, *Ryunosuke Takizawa*, *Farley Law*, *Keisuke Takahashi*, *Koichi Honda*, *Kohei Yamanoi*, *Matt Wang*, *Takumi Minami*, *Tomoyuki Johzaki*, *Seita Iizuka*, *Toshiharu Yasui*, *Akifumi Yogo*, *Fuka Nikaido*, *Yuji Fukuda*, *Takehito Hayakawa*, *Yuki Abe*, *Atsushi Sunahara*, *Masato Kanasaki*, *Yasuhiro Kuramitsu*, *Hiroaki Ohta* and *Shuji Nakamura*
Mutliple Diagnostics of Proton-Boron Fusion Reactions in High-Eneregy-Density Plasma
PRESENTER: *Shinsuke Fujioka*

ABSTRACT. Laser-based fusion energy is a revolutionary solution for a sustainable energy future. While, reliance on deuterium-tritium (D-T) fuel holds societal implementation challenges, such as resource availability and environmental concerns, including tritium leakage and neutron-induced activation. Our study explores alternative fusion fuels' viability through the proton-boron (p-11B) reaction. We have proposed a novel fuel geometry: a hollow spherical proton-boron configuration, contrasting the traditional pitcher-catcher setup. This geometry facilitates the acceleration and collision of protons and borons on the inner surface towards the center of the spherical fuel, creating a high-temperature, high-density proton-boron plasma core. We deployed multiple diagnostic techniques to investigate the p-11B fusion process. Alpha particles emitted from the p-11B reaction were measured using a Thomson parabola spectrometer and a solid-state track detector (CR-39), complemented by a machine learning-based track detection method for enhanced precision. This approach significantly surpasses alpha particle detection accuracy and analysis efficiency compared to the previous method. Additionally, the gamma-ray energy and half-life of byproducts of p-10B and p-11B reactions were measured with a Ge semiconductor detector; this measurement is crucial for assessing the reaction's frequency and efficiency. Experimental findings revealed that the hollow spherical-shell geometry induced more p-11B reactions than the flat-plate configuration, highlighting its advantageous feature. Yet, the reaction efficiency under the current conditions is lower than that of the pitcher-catcher approach, attributed to the insufficient focusing intensity of the LFEX laser for energetic proton acceleration in a blow-off plasma. The upgrade of the LFEX laser system involving implementation of new deformable mirrors aims to enhance the LFEX laser's focusing intensity to a peak of 1 x 10^20 W/cm^2 in 2024, expecting a significant boost in the p-11B reaction efficiency with hollow spherical fuels. Some of the diagnostic used in this study come from laboratory astrophysics

techniques. Refining these diagnostics through p-11B fusion study could contribute to deepen the understanding of staller elemental synthesis and interior high-energy events.

16:20 Farhat Beg, Mathieu Bailly-Grandvaux, Joowan Kim, Chris McGuffey, Krish Bhutwala, Jacob Saret and Phil Nilson

Energetic Proton Beam Heating of Targets Relevant to Proton Fast Ignition

PRESENTER: Farhat Beg

ABSTRACT. The study of intense ion beam generation and transport in varying conditions of temperature and density is important for a variety of applications including high-yield neutron sources [1], exotic isotope creation [2], and Fast Ignition (FI) of Inertial Fusion Energy (IFE) [3]. The ion beams generated in high intensity short pulse laser-matter interactions provide unique means to isochorically heat targets. We have carried out a series of experiments on the Omega EP laser to measure and characterize proton energy deposition. We for the first time used both time-resolved and time-integrated emission x-ray spectroscopy to investigate the bulk heating dynamics of a proton-heated target. The EP laser (450-900 J, 5-10 ps) was focused onto a cone-enclosed partial hemisphere to generate and focus an intense proton beam onto a 10 μm- or 25 μm-thick solid copper sample. Experimental data shows that the cone structure provides enhanced focusing of proton beam for efficient heating of the target. The streaked x-ray spectrometer diagnosed the Cu Kα1 and Kα2 line emissions with a spectral resolution of <2 eV and a time resolution of ~2 ps, allowing to resolve temperature-dependent shifts of the lines; these correspond to sample temperatures up to ~50 eV within ~35 ps, according to atomic kinetics simulations. We compared these results with hybrid-PIC simulations and found consistent temperature evolution, when accounting for the temporal spreading of the proton beam as it traverses the cone.

[1] D. P. Higginson et al., “Transition to efficient, unsuppressed bulk-target ion acceleration via high-fluence laser irradiation”, Phys. Rev. Research 4, 033113 (2022). [2] F. Hannachi et al., “Prospects for nuclear physics with lasers” Plasma Phys. Controlled Fusion 49, B79 (2007). [3] M. Roth et al., “Fast ignition by intense laser-accelerated proton beams” Phys. Rev. Lett. 86 436 (2001).

The experiment was conducted at the OMEGA Laser Facility with the beam time through the National Laser Users’ Facility (NLUF) under the auspices of the U.S. DOE/NNSA by the University of Rochester’s Laboratory for Laser Energetics under Contract DE-NA0003856. This material is based upon work supported by the U.S. DOE/NNSA Award Number DE-NA0004147, and by the University of California San Diego under contract DE-NA0003943 (NLUF).

16:40 David Stark

Evolution of Relativistic Self-Focusing of Laser Pulses in near-Critical Density Plasmas

ABSTRACT. We perform a particle-in-cell study of the propagation of a relativistic laser beam through a plasma that is near its relativistically modified critical density. In this regime, the modification of the index of refraction of the plasma by the intensity spatial profile in a Gaussian beam causes focusing to occur, often to greater intensities than achievable without the plasma optics. This can help usher in new regimes of laser-plasma interactions where more exotic effects like pair production can begin to occur. We first perform studies with semi-infinite pulses and track the changing focal properties of the plasma; we explore this evolution’s dependencies on various plasma parameters. Following this, we perform more realistic ultra-short pulse simulations and measure the optical properties of the plasma throughout the propagation of the pulse to better understand this mechanism on the timescales characteristic of these systems.

16:52 Lance Labun

Searching for Unruh Radiation in the Lab

ABSTRACT. Hawking radiation is one of the most striking consequences of combining quantum mechanics with gravity. However it is unlikely to be observable around astrophysical black holes. Instead, many related effects, especially Unruh radiation for accelerated observers, are more likely to have observationally verifiable signals. We explain how Unruh radiation manifests in the dynamics of highly accelerated electrons and its relationship to age-old problem of classical radiation reaction. We discuss the signatures of Unruh radiation in the highest gradient accelerators available in the lab: wakefield accelerators.

17:04 Gonzague Radureau and Claire Michaut

New Computational Method for Multigroup Radiative Hydrodynamics Using Artificial Intelligence: Analysis of Radiative Shock Structure

PRESENTER: Gonzague Radureau

ABSTRACT. Radiative hydrodynamics models the coupling between the dynamics of a hypersonic hot plasma and the radiation it produces or external radiation. Almost every numerical codes use simplified models, that are in most cases either limited or wrong. To accurately model the photon transport the HADES code was specifically developed [2, 3, 4]. Such a code is preferable for studying astrophysical objects, in which optically intermediate regions are still poorly modeled, yet commonly encountered within such phenomena. Indeed, it has already been used in previous simplified versions.

This code solves the general equations of radiative hydrodynamics in the 2D case and uses the M1 model for radiation transfer [1]. Moreover, the M1-multigroup model is employed to accurately represent the spectral behavior of light, involving the partitioning of the electromagnetic spectrum into groups. This enables the simulation of photon transport within each group [6].

Radiative shock have undergone extensive numerical investigation, notably through the utilization of codes such as CRASH, FLASH, HERACLES, Hyades. . . Nevertheless, despite this extensive analysis, the complete impact of photon frequency dependence remains a topic requiring further investigation. Only HERACLES, with its detailed treatment of photon transport, has undertaken simulations accounting for this factor, employing the M1-multigroup method [8].

Thanks to a machine learning approach, a field of development of artificial intelligence, we have implemented an innovative computation of the closure relation in the M1-multigroup model [5]. Then we have been able to renew the study of the influence of the spectral behaviour of photons, using up to 100 groups, with a precision that has never been exhibited before. Our findings reveal substantial disparities in the academic shock structure compared to prior simulations. We are excited to unveil these results at the upcoming HEDLA conference.

References

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PROGRAM FOR TUESDAY, MAY 21ST

Days: ↤ previous day next day ↦ all days

View: session overview talk overview

06:45-08:00 Session 9: Breakfast

LOCATION: Shula Grill Restaurant

08:00-08:05 Session 10: Announcements

CHAIR: *Local Organizing Committee*
LOCATION: Horizon Grand Ballroom

08:05-09:30 Session 11: Atomic Physics at High Pressures

CHAIR: *Dominik Kraus*
LOCATION: Horizon Grand Ballroom

08:05 *Tilo Doeppner*
Observing the Onset of Pressure-Driven K-Shell Delocalization

ABSTRACT. We have developed an experimental platform for x-ray Thomson scattering (XRTS) at NIF to characterize plasma conditions in ICF indirectly-driven capsule implosions near stagnation [1,2]. This enabled us to investigate up to 30 times compressed ablator materials reaching pressures above 3 Gigabars, at conditions where the distance between the nuclei becomes comparable to the extent of the core shell bound states, which will eventually lead to their pressure ionization. In this talk we will present results from experiments with beryllium shells. We observe reduced elastic scattering for the most extreme conditions [2]. We interpret this reduction as the precursor of pressure ionization of the remaining K-shell electrons, that is, a strongly modified bound state. The beryllium charge state inferred from the data is considerable higher than standard models predict but agrees well with results from DFT simulations [2,3]. Accurate modelling of the K-shell occupation of light elements is not only imperative for creating predictive capabilities for ICF implosions but also for improving our understanding of giant planets and dwarf stars. Our experiments yield valuable benchmarks for this process and demonstrating a complex pathway of pressure ionization.

[1] D. Kraus et al., J. Phys. Conf. Ser. 717, 012067 (2016). [2] T. Döppner et al., Nature 618, 270 (2023). [3] M. Bethkenhagen et al., Phys. Rev. Res. 2, 023260 (2020).

*This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract No. DE-AC52-07NA27344 and supported by Laboratory Directed Research and Development (LDRD) Grants No. 18-ERD-033 & 24-ERD-044.

08:25 *Mike MacDonald*, *Carlos Di Stefano*, *Tilo Doeppner*, *Luke Fletcher*, *Kirk Flippo*, *Dan Kalantar*, *Elizabeth Merritt*, *Suzanne Ali*, *Peter Celliers*, *Rick Heredia*, *Scott Vonhof*, *Rip Collins*, *Jim Gaffney*, *Dirk Gericke*, *Siegfried Glenzer*, *Dominik Kraus*, *Alison Saunders*, *Derek Schmidt*, *Christopher Wilson*, *Rich Zacharias* and *Roger Falcone*
The Colliding Planar Shocks Platform to Study Warm Dense Matter and Laboratory Astrophysics at the National Ignition Facility
PRESENTER: *Mike MacDonald*

ABSTRACT. We have developed an experimental platform to study warm dense matter at the National Ignition Facility that uses colliding planar shocks to produce uniform plasma conditions and enable high-precision measurements of warm dense matter [1]. The Colliding Planar Shocks (CPS) platform currently uses simultaneous x-ray Thomson scattering and x-ray radiography to measure the density, electron temperature, and ionization state at pressures approaching 100 Mbar. The CPS platform creates a large volume of uniform plasma in the x-ray scattering volume, significantly improving the precision of the measurements necessary to test models for the equation of state and ionization potential depression in the warm dense matter regime. Here, we present the design of the CPS platform, compare hydrodynamic simulations to x-ray radiography and x-ray scattering data from initial experiments studying hydrocarbons, and propose future directions for the platform for laboratory astrophysics experiments.

[1] M. J. MacDonald et al., Phys. Plasmas 30, 062701 (2023).

08:45 *Tobias Dornheim*
Breaking the Vicious Cycle of Warm Dense Matter Diagnostics

ABSTRACT. Matter at extreme densities and temperatures displays a complex quantum behavior that is characterized by Coulomb interactions, thermal excitations, and partial ionization. Such warm dense matter (WDM) is ubiquitous throughout the universe and occurs in a host of astrophysical objects such as giant planet interiors and white dwarf atmospheres. A particularly intriguing application is given by inertial confinement fusion, where both the fuel capsule and the ablator have to traverse the WDM regime in a controlled way to reach ignition.

In practice, rigorously understanding WDM is highly challenging both from experimental measurements and numerical simulations [1]. On the one hand, interpreting and diagnosing experiments with WDM requires a suitable theoretical description. One the other hand, there is no single method that is capable of accurately describing the full range of relevant densities and temperatures, and the interpretation of experiments is, therefore, usually based on a number of de-facto uncontrolled approximations. The result is the vicious cycle of WDM diagnostics: making sense of experimental observations requires theoretical modeling, whereas theoretical models must be benchmarked against experiments to verify their inherent assumptions.

In this work, we outline a strategy to break this vicious cycle by combining the X-ray Thomson scattering (XRTS) technique [2] with new ab initio path integral Monte Carlo (PIMC) capabilities [3,4,5]. As a first step, we have proposed to interpret XRTS experiments in the imaginary-time (Laplace) domain, which allows for the model-free diagnostics of the temperature [6] and normalization [7]. Moreover, by switching to the imaginary-time, we can directly compare our quasi-exact PIMC calculations with the experimental measurement [5]. This opens up novel ways to diagnose the experimental conditions, as we have recently demonstrated for the case of strongly compressed beryllium at the National Ignition Facility.

Our results open up new possibilities for improved XRTS set-ups that are specifically designed to be sensitive to particular parameters of interest [8]. Moreover, the presented PIMC capabilities are important in their own right and will allow for a gamut of applications, including equation-of-state calculations and the estimation of structural properties and linear response functions.

[1] T. Dornheim et al., Phys. Plasmas 30, 032705 (2023) [2] S. Glenzer and R. Redmer, Rev. Mod. Phys. 81, 1625 (2009) [3] T. Dornheim et al., J. Phys. Chem. Lett. 15, 1305-1313 (2024) [4] T. Dornheim et al., arXiv:2403.01979 [5] T. Dornheim et al., arXiv:2402.19113 [6] T. Dornheim et al., Nature Commun. 13, 7911 (2022) [7] T. Dornheim et al., arXiv:2305.15305 [8] Th. Gawne et al., arXiv:2403.02776

09:05 David Bishel, Philip Nilson, D. Alexander Chin, John Ruby, Ethan Smith, Edward Marley, Reuben Epstein, Suxing Hu, Igor Golovkin, Ming Gu, J. Ryan Rygg and Gilbert Collins
Dense Plasma Line Shifts of Inner-Shell Transitions
PRESENTER: David Bishel

ABSTRACT. The frontier of atomic physics lies in the dense plasma regime. At electron densities Ne ≳ 10^{25} cm^{−3} characteristic of stellar interiors and inertial fusion plasmas, atomic transition energies shift due to electrostatic interactions between the radiator and nearby charged particles. Though predicted by theory, experimentally isolating such line shifts and identifying the dependence on the thermodynamic state constitute a step change in understanding and will enable new spectroscopic diagnostics of dense plasmas. In plastic shells hosting a Cr tracer layer imploded at the OMEGA-60 laser facility, 1s−2p absorption lines from L-shell Cr ions present a decreasing red-shift as the stagnated shell releases from peak compression Ne ≈ 10^{25} cm^{−3}. The thermodynamic conditions and opacity of the Cr layer are constrained using a forward model of the measured spectrum. Under these constraints, Doppler and satellite contributions are insufficient to describe the magnitude of the red-shift. The case for the plasma polarization shift causing the residual shift is presented.

09:30-10:00	Coffee Break
10:00-11:45	Session 12: Magnetized Plasma and Experimental Platforms

CHAIR: Bruce A. Remington
LOCATION: Horizon Grand Ballroom

10:00 Felicie Albert
The Jupiter Laser Facility: a Kilojoule-Class Laser for Producing and Exploring Extreme States of Matter

ABSTRACT. This talk will present opportunities for high energy density laboratory astrophysics experiments at LLNL’s Jupiter Laser Facility (JLF). The facility has just completed a 4-year long refurbishment and is welcoming users back through the LaserNetUS network. In addition to scientific discovery, JLF has historically served as a steppingstone to larger experiments at the NIF and OMEGA lasers. JLF supports multiple laser platforms: Titan, Janus TA1, and COMET. Titan’s two-beam system is composed of a nanosecond, kilojoule long-pulse beam and a short- pulse beam with 1 to 10 ps pulses and energies up to 300 J, depending on pulse duration, and these beams can be used together or independently. JLF’s Janus system has two independent beams, each of which can produce 1 kJ at 1.053 μm with pulse lengths from 1 to 20 ns. The system fires approximately every 30 minutes and offers frequency doubling, as well as a variety of pulse shapes. COMET’s flexible configuration, which was designed primarily to generate laboratory x-rays, offers uncompressed pulse lengths from 500 ps to 6 ns, compressed pulses down to 0.5 ps, and beam energies up to 10 J.

10:20 *Alexander Velikovich*, *Calvin Zulick*, *Yefim Aglitskiy*, *Max Karasik* and *Andrew Schmitt*
Turbulence in Shock Interaction with Density Inhomogeneities and Foam Hugoniot Experiments on the Nike Laser Facility
PRESENTER: *Alexander Velikovich*

ABSTRACT. Shock front interaction with random density nonuniformities in the shocked material is a problem of interest in astrophysics and inertial confinement fusion (ICF). Astrophysical media are typically nonuniform, featuring density clumps and clouds of various scales. Many indirect- and direct-drive ICF target designs involve empty or DT-wicked plastic foams, which are strongly nonuniform on the foam cell scale. The shock interaction with the inhomogeneous density field generates turbulence in the shocked fluid, affecting the shock propagation. Numerical [1-6] and theoretical [7, 8] studies of this effect indicate a reduction of the shock density compression, the "undercompression" [2], compared to an instantly homogenized material of the same average density and equation of state (EOS). Such an effect could be observable in shock Hugoniot experiments with low-density CH foams, but the data accumulated since the 1970s is relatively scarce and inconclusive. We discuss the results of the empty CH foam Hugoniot measurements performed on the Nike krypton-fluoride laser facility at NRL. The Nike Hugoniot platform [9] combines a uniquely uniform laser drive (less than a 0.25% time-averaged laser drive intensity variation in the overlapping beams within a 400-um diameter flat-top focal spot) with high-resolution monochromatic X-ray streak imaging, enabling experiments in previously unexplored parameter ranges, with shock velocities and pressures up to 100 km/s and 9 Mbar, respectively. The observed trajectories of the shock front and the ablation piston deviated from straight lines, indicating steady shock propagation in the foam, by less than 1%. The Nike Hugoniot data obtained with 100 mg/cc DVB foams [9] supports the prediction of shock compression lower than that calculated from tabulated EOS, such as SESAME. However, more recent Nike data obtained with lower-density DVB foams, from 73 to 94 mg/cc, and with structured 3D-printed foams with densities from 64 to 144 mg/cc indicates higher levels of shock density compression. We discuss possible reasons for this discrepancy and the unresolved physics issues of shock interaction with a density inhomogeneity field. Work supported by U.S. DOE/NNSA.
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10:40 *Pablo J. Bilbao*, *Charles D. Arrowsmith*, *Jack Halliday*, *Vasiliki Stergiou*, *Sifei Zhang*, *Thales Silva*, *Bruno Buonomo*, *Fabio Cardelli*, *Eleonora Diociaiuti*, *Domenico di Giovenale*, *Claudio di Giulio*, *Luca Fogetta*, *Robert Bingham*, *Luis O. Silva* and *Gianluca Gregori*
Laboratory Analogues of Astrophysical Coherent Electron Cyclotron Maser Processes
PRESENTER: *Pablo J. Bilbao*

ABSTRACT. We present theoretical and simulation results for a novel laboratory platform capable of directly studying the electron cyclotron maser instability in the laboratory. Recent advances in observation [1,2], theory [3], and simulations [4,5] have fueled a renewed interest in the electron cyclotron maser instability as a mechanism for generating the brightest astrophysical radiation, including pulsar emissions and FRBs. This instability amplifies coherent electromagnetic radiation within magnetized plasmas due to an inverted Landau population. Distributions with horseshoe or ring-beam momentum shapes, distinctly influence maser dynamics and emission signatures [6,7]. Pair plasma beams in compact object magnetospheres are predicted to become maser unstable through various processes depending on specific conditions. The first laboratory realization of an electron-positron plasma beam [6] opens a new door to directly study beam-plasma instabilities in magnetic fields mimicking pulsars and magnetars. We propose two distinct laboratory platforms designed to generate maser-unstable plasmas relevant to diverse astrophysical scenarios. The first investigates the interaction of pair-plasma beams with a magnetic mirror, analogous to plasma infalling in a pulsar polar cap. The second platform utilizes betatron cooling, mimicking synchrotron cooling experienced by astrophysical beams. Our work offers, for the first time, the possibility of laboratory experiments directly capable of studying coherent radiation mechanisms relevant to FRBs under current experimental conditions, potentially leading to a deeper understanding of unexplained observations.

[1] The CHIME/FRB Collaboration, Nat. 587.7832 (2020): 54-58 [2] C. P. Hu, et al. Nat. 626.7999 (2024): 500-504 [3] W. Lu, and P. Kumar. MNRAS 477.2 (2018): 2470-2493 [4] B. D. Metzger, et al. MNRAS 485.3 (2019): 4091-4106 [5] P. J. Bilbao and L. O. Silva. Phys. Rev. Lett. 130.16 (2023): 165101 [6] D. C. Speirs, et al. Phys. Plasmas 17.5 (2010) [7] R. A. Cairns, et al. Phys. Plasmas 18.2 (2011) [6] C. D. Arrowsmith, et al. arXiv:2312.05244 (2023)

11:00 *Sergey Lebedev*
Experiments with Pulsed-Power Driven High Energy Density Magnetized Plasmas: Rotation, Turbulence and Shocks

ABSTRACT. In this talk we will discuss recent experiments performed at the MAGPIE facility at Imperial College in which we use a combination of X-ray-drive, generated by imploding wire arrays, with multi-Tesla B-fields produced by the Z-pinch current [1], to form magnetized high-density plasmas for scaled modeling of astrophysical dynamics [2]. We will present investigations of the effects of magnetic fields on the development of turbulence in colliding, radiatively cooling plasma flows. We will also present results from a modified x-ray driven

set-up complementary to described in [3], allowing introduction of differential rotation to free-boundary laboratory plasmas.

[1] J.W.D. Halliday, et al., "Investigating radiatively driven, magnetized plasmas with a university scale pulsed-power generator", Physics of Plasmas, 29, 042107 (2022). [2] S.V. Lebedev, A. Frank, and D.D. Ryutov, "Exploring astrophysics-relevant magnetohydrodynamics with pulsed-power laboratory facilities", Rev. Mod. Phys., 91, 025002 (2019). [3] V. Valenzuela-Villaseca et al., "Characterization of Quasi-Keplerian, Differentially Rotating, Free-Boundary Laboratory Plasmas", Phys. Rev. Lett., 130, 195101 (2023).

11:20 *Patrick Poole*, *Tanim Islam*, *Robert Tipton* and *Joe Wasem*
Developing X-Ray Sources for Plantary Defense Studies at Omega and NIF
PRESENTER: *Patrick Poole*

ABSTRACT. The DART (Double Asteroid Redirection Test) recently demonstrated successful deflection of an asteroid with kinetic forces, but for larger and/or faster bodies a nuclear detonation may be able to provide a similar but thermonuclear deflection. This requires an understanding of how possibly novel asteroid material makeups behave with respect to a detonation, in particular as the height of burst is varied. An platform has been developed for NIF using an x-ray source that is hydrodynamically scaled from a nuclear detonation using one quad of beams (~10 kJ) incident into a small (2 mm diameter) Sn-doped CH capsule. Simulations of this x-ray source and recent experiments on Omega-EP and NIF will be presented.

11:32 *Katherine Marrow*, *Stefano Merlini*, *Jergus Strucka*, *Aidan Crilly*, *Benjamin Duhig*, *Thomas Mundy*, *Jack Halliday*, *Lee Suttle*, *Jerry Chittenden* and *Sergey Lebedev*
X-Ray Driven Laboratory Astrophysics Experiments on MAGPIE Pulsed-Power Generator
PRESENTER: *Katherine Marrow*

ABSTRACT. Radiative cooling effects can strongly influence the structure of shocks formed by colliding supersonic plasma flows, leading to the growth of instabilities and turbulence. Here, we present experiments conducted at the MAGPIE pulsed-power generator (1.4 MA, 240 ns rise time) on colliding plasma flows produced from the ablation of solid targets using a wire array z-pinch as an x-ray source. A wide range of target geometries and materials have been considered for different experiments, exploring the interaction of flows in the presence of an ambient magnetic field supported by the current pulse flowing through the wire array. Ablating two parallel planar targets results in two counter-propagating, supersonic plasma flows which form a dense layer of shocked, stagnated plasma at the collision plane. This 'stagnation layer' is consistent with a 1D accretion shock model with $\gamma \leq 1.2$. By changing the position and orientation of the targets with respect to the ambient magnetic field, we can study the effect of magnetic field on the flow, while radiative cooling effects are explored by changing target material. Placing the planar surfaces at an angle to each other to form a wedge-shaped target opens the possibility of producing radiatively driven jets, where we can investigate factors such as the collimation of the jet in relation to the thermal properties of the plasma. Finally, to investigate inhomogeneous plasmas, the solid targets are replaced with 3D printed meshes to produce spatially modulated colliding plasma flows. The collision of modulated plasmas results in the formation of a turbulent layer which can be easily diagnosed using various laser-based diagnostics. This set of experiments aims to explore the effects of magnetic fields on the suppression of the structures formed within the plasma.

12:00-13:30 Lunch Break

13:30-15:10 Session 13: Materials at High Pressures II

CHAIR: *Ivan Oleynik*
LOCATION: Horizon Grand Ballroom

13:30 *Danae Polsin*, *Amy Jenei*, *Andy Krygier*, *Xuchen Gong*, *Stephen Burns*, *Federica Coppari*, *Linda Hansen*, *Margaret Huff*, *Malcolm McMahon*, *Marius Millot*, *Reetam Paul*, *Raymond Smith*, *Jon Eggert*, *Eva Zurek*, *Matthew Signor*, *Zechen Liu*, *Kevin Vencatasamy*, *G. W. Collins* and *J. R. Rygg*
Structural Complexity in Ramp-Compressed Sodium to 480 GPa
PRESENTER: *Danae Polsin*

ABSTRACT. At high-energy-density conditions, a new realm of quantum behavior emerges including electron localization, structural complexity, and core-electron chemistry. Sodium (Na) behaves particularly unusual at these conditions because of its very high compressibility and lone valence electron. Normally a shiny ideal metal, Na transforms to a topological insulator at 200 GPa. This topologically insulating phase (hP4) is due to the valence electrons occupying interstitial positions of its crystalline lattice rather than the orbitals centered on ionic cores. Using lasers as high-pressure drivers, we report the structural and electronic properties of Na at the most extreme compressions yet studied. X-ray diffraction measurements to 480 GPa and 2000 K reveal unexpected new phases. Simultaneous reflectivity measurements suggest a dramatic drop in the conductivity of both the solid and fluid phases. These data together with ab initio evolutionary structure searches reveal a rich structural competitiveness than extends to greater than 300 GPa and thousands of degrees Kelvin. Recent experiments on ramp-compressed sodium at the National Ignition Facility will provide an experimental basis for understanding electron localization in traditionally simple metals at significant compressions.

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13:50 *Kyla de Villa*, *Felipe Gonzalez-Cataldo* and *Burkhard Militzer*
Proton Superionicity and Double Superionicity in Planetary Ices
PRESENTER: *Kyla de Villa*

ABSTRACT. Superionic phases, in which protons diffuse like a liquid through stable lattices of heavier nuclei, have been observed experimentally and computationally in water and ammonia at high pressures, and have been predicted for a number of proton rich planetary materials. Here we describe a novel state of matter in the H-C-N-O chemical space: double superionicity. With density functional molecular dynamics and machine learning molecular dynamics simulations we show that hydrogen and one heavier species (either C or N) simultaneously diffuse at elevated temperature while the heaviest nuclei provide a stable sublattice until the entire material melts at yet higher temperature. We further demonstrate that proton superionicity is ubiquitous in planetary ices (focusing on H-C-N-O and N-H materials) at sufficiently high pressure and temperature. Superionic and doubly superionic phases may exist in the interiors of Uranus and Neptune and thus may influence their magnetic dynamo because of their high ionic conductivities.

14:10 *Terry-Ann Suer*, *Stephanie Brygoo*, *Grigory Tabak*, *Shuai Zhang*, *Michelle Marshall*, *Ryan Rygg*, *Paul Loubeyre*, *Gilbert Collins* and *Raymond Jeanloz*
Shock Compression of H-Rich Mixtures at Giant Planet Interior Conditions
PRESENTER: *Terry-Ann Suer*

ABSTRACT. Helium is strongly depleted in the atmospheres of gas giant planets relative to bulk solar compositions [1]. A proposed mechanism for this depletion is the phase separation from hydrogen, the main component of gas giant planets [2, 3]. While recent shock compression experiments support this hypothesis [4], the miscibility behavior of hydrogen with other important planetary components has yet to be experimentally explored at warm dense conditions. We combined static and dynamic compression to investigate the equation of state and reflectivity (an indicator of miscibility) of H2-Ne (Ne/H = 0.2) and H2-H2O (H20/H = 1:1) at the conditions of gas and ice giant interiors. Preliminary results on H2-Ne indicate miscibility at combined pressures and temperatures of up to 150 GPa and 20,000 K. H2 and H2O appear to form a mixed fluid state at ~350 GPa and ~10,000 K. Analyses of these systems are ongoing, and follow-up experiments will utilize different mixing ratios and probe a wider range of pressure-temperature conditions to further explore the phase relations of these mixtures.

This material is based upon work supported by the Department of Energy [National Nuclear Security Administration] University of Rochester "National Inertial Confinement Fusion Program" under Award Number DE-NA0004144.

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14:30 *Ryan Rygg*
Anomalous Sound Speed in Warm Dense Matter

ABSTRACT. Recent experiments in shocked liquid deuterium [Fratanduono et al, Phys. Plasmas 26, 012710 (2019)] measured anomalously low sound speed near 200 GPa compared to theoretical models. The observed speed is shown to be consistent with a slowing of longitudinal compression waves that velocity-match to an electrostatic potential generated by the ion-acoustic plasma mode. This velocity resonance is expected to occur at electron degeneracies between approximately 2 and 4 (ratio of Fermi energy to thermal energy). The experimental evidence implies a reduction in adiabatic index compared to all theoretical models in this thermodynamic band. A reduced adiabatic index modifies our understanding of stellar structure, convective thresholds, and pulsation periods for astrophysical bodies such as brown, red, and white dwarf stars.

14:50 *Zhandos Moldabekov*
Dynamic Structure Factor and Dielectric Properties of Warm Dense Hydrogen Form Linear-Response Time-Dependent Density Functional Theory

ABSTRACT. Matter under extreme densities and temperatures—often referred to as warm dense matter (WDM)— is pivotal for a number of cutting-edge technological applications such as the discovery and synthesis of novel materials and hot-electron chemistry. A particularly important and timely application is given by inertial confinement fusion, where the fuel capsule has to traverse the WDM regime in a controlled way towards ignition. Unfortunately, the theoretical understanding of such extreme states is rendered notoriously difficult by the complex interplay of a variety of physical effects (Coulomb coupling, thermal excitations, quantum degeneracy, etc.). In practice, density functional theory (DFT) constitutes the workhorse of WDM theory. In this work, we present our results on the dynamic structure factor and dynamic dielectric function of warm dense hydrogen computed

from first principles using linear response time-dependent density functional theory. In addition, we discuss the relevance of the thermal exchange-correlation effects for the electronic structure in warm dense hydrogen [1-4].

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15:10-15:40 Coffee Break

15:40-17:30 Session 14: Poster Session

LOCATION: Opal Room

Abigail Armstrong, Joshua Sauppe, Hui Li, Elizabeth Merritt, Adam Reyes, Edward Hansen and Petros Tzeferacos

FLASH Simulations of Biermann-Generated Magnetic Field in a Convergent System

ABSTRACT. Astronomical observations have confirmed the existence of ordered magnetic fields across a broad range of spatial and magnitude scales. From interstellar scales on the order of 10-5 G [1], to cosmic web filaments with an upper limit of 10-9 G [2]. These magnetic fields can be relevant in galactic dynamics [3], play an important role in stellar formation [4], and affect other physical processes such as cosmic ray acceleration [5] and thermal conduction [4]. The Biermann Battery mechanism paired with turbulent dynamo has been put forward as a potential mechanism for the generation, amplification, and sustainment of these observed fields [6, 1]. Recent planar experiments [7, 8] have successfully demonstrated turbulent dynamo in the laboratory for the first time. Theoretical work suggests that magnetic fields may be generated in inertial confinement fusion implosions [9], however diagnosing such systems remains a challenge. In contrast, cylindrical implosions retain the effects of convergence while allowing direct diagnostic access to the interior of the target by viewing down the axis of the system. Hydrodynamic instabilities within these implosions can grow due to the Rayleigh-Taylor (RT) [10, 11], and the Richtmyer-Meshkov (RM) [12, 13] instabilities, as well as the Bell-Plesset (BP) [14, 15] effect, and, at late times, turbulence may develop. Los Alamos National Laboratory has a long history of success studying instability growth in convergent systems using such platforms [16], yet the platform has not been designed for accessing physical regimes where Biermann battery can operate effectively, and magnetic resistivity does not diffuse the fields faster than the dynamically relevant time scales. Using the existing cylindrical implosion platform as a starting point for examining magnetic fields generated by the Biermann Battery mechanism, we present preliminary 2D FLASH simulations that indicate the viability of using this platform to study Biermann generated fields in a convergent geometry. We also analyze the potential growth of such fields due to the development of turbulence once the RT/RMI has left the linear stage.

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Tristan Bachmann, Jessica Pilgram, Marissa Adams, Mario Manuel, Carmen Constantin, Haiping Zhang, Lucas Rovige, Peter Heuer, Robert Dorst, Sofiya Ghazaryan, Marietta Kaloyan, Derek Schaeffer, Christoph Niemann and Petros Tzeferacos

Laboratory Astrophysics Exploration of Early Universe Magnetogenesis via Biermann Battery

ABSTRACT. Magnetic fields are pervasive on cosmological and galactic scales, and understanding their formation and evolution is essential to our understanding of modern cosmology. One of the predominant proposed mechanisms for the origin of these fields is via the thermoelectric Biermann battery effect, which describes the spontaneous generation of magnetic fields due to non-parallel density and temperature gradients in plasmas. Though the effect is difficult to observe directly in the intergalactic medium due to its relatively small magnitude and the large spatial scales along which measurements are made, rapid growth in the field of laboratory astrophysics in recent decades now allows us to use scaling relations to investigate these phenomena on laboratory scales. Using FLASH, a high-performance radiation-hydrodynamics code with extended magnetohydrodynamic terms, we collaborate with experimentalists at UCLA to model the generation of Biermann-driven fields in such a laboratory setting, using high repetition rate laser produced plasmas at a frequency of ~1 Hz. We validate the FLASH code at new spatiotemporal regimes, and use these newly validated capabilities to assist in the modeling and design of continuing laboratory astrophysics experiments which introduce a Nitrogen fill to the target chamber in order to facilitate shocks in the system, and to perform large scale simulations investigating the generation and subsequent amplification of seed fields and their impact on LSS.

Léa Dollerschell, Lucile Van Box Som, Bruno Albertazzi, Anabella Araudo, Clotilde Busschaert, Alexis Casner, Nicolas Charpentier, Ronan Devriendt, Marin Fontaine, Thibault Goudal, Manuel Jullien, Yann Marchenay, Diego Oportus, Bruno Peres, Gabriel Rigon, Youichi Sakawa, Angelos Triantafyllidis and Emeric Falize

The CIRENE Project : Modeling Internal Novæ Ejectas Radiative Shocks in the Laboratory.

ABSTRACT. A nova is a thermonuclear outburst on the surface of an accreting white dwarf [1]. At least a part of the accretion layer mostly composed of hydrogen, is ejected at high speeds of 200 to 5000 km/s, and shocks arise when a fast outflow encounters a slower outflow. They are very rich physical processes in novæ, as evidenced by their multi-wavelength radiation [2]. We can observe a highly absorbed X-ray radiation, which re-emerges in the UV-optical range. This indicates complex radiative shock structures that happen as a rather spherical wind crashes into a torus-shaped medium surrounding the binary system [2, 3]. It is crucial to validate a precise model of this shock structure because it plays a central role to explain dust formation or particle acceleration [4, 5].

However, internal shocks are buried deep within the ejecta which prevents direct observations : the physics of the structure must be infered. Every alternative approach that can provide direct insight into one of these objects is of primary importance. In this context, we have recently developed a new research program: the CIRENE project (Chocs Internes Radiatifs dans les Ejectas de NovaE). Its main objective is to improve the modeling and the understanding of radiative accretion shocks occurring in novæ ejectas by coupling theoretical, numerical and experimental studies. Recent theoretical and numerical works [6, 7] have demonstrated that the double-shock structure can be simulated. In this poster, we will present the first radiative hydrodynamics simulations of the double shock structure, performed with the RAMSES code [8] and we will compare these results to an improved version of the theoretical 1D model of [9]. These simulations will highlight the cooling processes as well as the instabilities that can develop in this structure and thus provide a better understanding of the formation of the thin cold central layer. Moreover, thanks to many works on the scalability of radiation hydrodynamics flow [10], we have proved that adapted scaling laws can be applied to reproduce these phenomena in a laboratory with powerful lasers [7]. To this end, we propose in this poster a target design for the LULI2000 laser facility in order to observe the double-shock structure for the very first time. We will also present in the poster the numerous 1D and 2D simulations of the experiment we conducted with the Troll code to optimize the target characteristics. These experiments will allow us to validate the classical model of internal radiative shocks.

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Margaux François, Derek Schaeffer, Jean-Luc Dubois, Emmanuel D'Humières and Xavier Ribeyre

Preparatory Simulations with FLASH of a Laboratory Astrophysics Experiment on the NIF Laser-Facility

ABSTRACT. During violent astrophysical phenomena very energetic particles can be accelerated, these are the cosmic rays. Shocks in particular are likely to be accelerating structures for cosmic rays via processes such as those presented by Fermi in 1949 [1]. Due to the impossibility of in situ measurements, laboratory astrophysics experiments are necessary to study the acceleration processes of cosmic rays [2]. One way to do laboratory astrophysics is to use high power lasers like the National Ignition Facility (NIF) in the United States of America or LMJ in France, i.e. megajoule class laser facilities. In particular to obtain high Mach number shocks high power lasers must be used [3]. There will be shots at the NIF to study for the first time in the laboratory non-thermal ion populations generated by magnetized high-Mach-number quasi-parallel (magnetic field

parallel to the shock velocity) collisionless shocks. To prepare and analyse this experiment hydrodynamic simulations with the code FLASH [4] have been performed. The collisional shock characteristics are required as input for kinetic plasma simulations that can model the development of the collisionless shock and the associated particle acceleration. The analysis of the FLASH simulation results will be presented, and the transition towards the kinetic simulations will be discussed. Shots on the OMEGA laser facility were also performed (October 2023) to prepare the experiment on NIF. To understand the results of those shots, additional FLASH simulations were run. The analysis of these additional simulations will be presented, as well as the scaling of the collisional shock velocity as a function of the main laser and target parameters.

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Thomas Gawne, *Hannah Bellenbaum*, *Luke B Fletcher*, *Thomas R Preston*, *Oliver S Humphries*, *Dominik Kraus*, *Michael J MacDonald*, *Zhandos A Moldabekov*, *Chongbing Qu*, *Jan Vorberger* and *Tobias Dornheim*
Effects of Mosaic Crystal Instrument Functions on X-Ray Thomson Scattering Diagnostics

ABSTRACT. Mosaic crystals, with their high integrated reflectivities, are widely-employed in spectrometers used to diagnose high energy density systems. X-ray Thomson scattering (XRTS) has emerged as a powerful diagnostic tool of these systems, providing direct access to important properties such as the temperature via detailed balance. However, the measured XRTS spectrum is broadened by the spectrometer instrument function (IF), and without careful consideration of the IF one risks misdiagnosing system conditions. Here, we consider in detail the IF of mosaic crystals and how the broadening varies across the spectrometer. Notably, we find a strong asymmetry in the shape of the IF towards higher energies, suggesting temperatures inferred via detailed balance can be overestimated if an approximate symmetric IF is used.

Xuchen Gong, *Michelle Marshall*, *Mary Kate Ginnane*, *J. Ryan Rygg* and *Gilbert W. Collins*
Extending Sub-Nanosecond Optical Pyrometry Temperature Measurement to <4000 K
PRESENTER: *Xuchen Gong*

ABSTRACT. Streaked Optical Pyrometer (SOP) measures the temporally and spatially resolved brightness temperature of a dynamically compressed material by assuming it radiates like a blackbody. On laser facilities such as OMEGA and OMEGA EP at Laboratory for Laser Energetics, the measurement duration is typically several tens of nanosecond, with time resolution <100 ps. Today, typical SOP can measure temperature above ~4000 K. As temperature decreases, the number of photons emitted by the target drops precipitously, resulting in signals buried in detector noises. In this work, we present a statistical model that allows SOP data reduction with high temporal and spatial resolution at temperatures where the traditional analysis method fails, extending the capability of SOP to measure temperatures of relatively cold targets.

Hannah Hasson, *Irem Nesli Erez*, *Imani West-Abdallah*, *James Young*, *Jay Angel*, *Chiatai Chen*, *Euan Freeman*, *John B. Greenly*, *David A. Hammer*, *Eric Sander Lavine*, *William M. Potter* and *Pierre-Alexandre Gourdain*
Rotating Plasma Outflows with Tunable Magnetic Fields Resembling YSO

ABSTRACT. Rotating bipolar outflows are commonly observed in the Young Stellar Object (YSO) phase of early star formation, and are thought to be influenced by complex magnetic field structures. Yet, the conditions of the launch region for these flows remain unclear due to limited resolution in observations. We employ a scalable laboratory experiment of a pulsed-power-driven cylindrical wire array in order to generate radially collapsing flows that transition into bipolar outflows. By introducing tunable current path elements around the wire array, we enable the ratio of axial to azimuthal magnetic field (B_z/B_θ) to be varied by minor changes in the 3D-printed load design. This allows us to add rotation in the flows by introducing B_z or by pushing the radial plasma streams off-axis as they merge. Our experiment is driven by a ~1 MA, 200 ns rise current pulse on the COBRA Marx driver, and is diagnosed with optical Thomson scattering, interferometry, inductive probes, and gated UV or optical imaging. We calculate scaling parameters for our system using velocity, electron temperature, magnetic field and density measurements, and compare our outcomes to simulations from the PERSEUS extended-MHD code.

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Haibo Huang, *Kevin Sequoia*, *Ruben Santana*, *Masashi Yamaguchi*, *Pavel Lapa*, *Neal Tomlin* and *Michael Farrell*
Solar Opacity Motivated AutoEdge Xray Opacity Measurement, X-Ray Database Revision, and Validation by RBS Method

ABSTRACT. With the emergence of High Energy Density (HED) physics, scientists can now replicate extreme stellar conditions within controlled laboratory environments on Earth. This advancement enables the in-depth study of astrophysical phenomena and addresses national security concerns. These experiments demand precise knowledge of the areal density of the targets. However, the traditional validation method, Rutherford BackScattering (RBS), necessitates destructive measures to achieve the required precision and offers limited probing depth. Consequently, it can only be applied to surrogate targets. General Atomics has pioneered a laboratory-based AutoEdge method, ensuring x-ray transmission measurements with synchrotron-

like precision and accuracy. This innovative approach operates continuously, supporting 24/7 target production for real targets intended for large-scale HED facilities like the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory (LLNL) and the Z Facility at Sandia National Laboratories (SNL). By utilizing the x-ray opacity database, also known as the mass attenuation coefficient database, nondestructive determination of areal density from x-ray transmission becomes possible.

While routinely achieving a 1% precision in areal density, there exists a potential ~5% systematic error contingent upon the x-ray opacity database employed for data conversion. Although the x-ray opacity of elements was extensively studied from the 1920s to the 1980s, widely used tabulated x-ray databases like NIST-XCOM (Hubbell), NIST-FFAST (Chantler), CXRO (Henke), SNL (Biggs), and LLNL (McMaster) demonstrate consistency only ~ ±10 percent, occasionally worse, even for common elements. These discrepancies, largely unknown, significantly impact the interpretation of High Energy Density (HED) experiments. For instance, anomalies in Solar opacity must be referenced to room temperature behavior. Since areal density computation relies on x-ray transmission using an opacity database, it is akin to measuring length with an inaccurate meter stick. Every measurement made using this flawed reference will be proportionally incorrect. To address this database inconsistency, we opted to employ the AutoEdge method in reverse, analyzing free-standing single-element metal foils with accurately determined areal density via gravimetric methods. We developed a methodology to refine the x-ray opacity database within the photon energy range of 3 to 17 keV. In this process, we contributed to the 'International Initiative on X-ray Fundamental Parameters' (IIFP), a collaboration led by NIST, CEA, and PTB. Our work on Ni, Fe, and Au has been completed, demonstrating an agreement of ~1% with gravimetric measurements. Additionally, we established a 1% consistency between AutoEdge and RBS measurements for Fe foils and a 1% consistency between AutoEdge and synchrotron measurements for Ni.

The AutoEdge method has become integral to the characterization of all opacity targets utilized in the US national program, including both ZAPP and Discovery Science targets. This enhanced metrology capability has paved the way for the engineering of new target types, such as SiO_2 targets up to 15 μm in thickness, and mixed SiO_2 and MgO targets for solar opacity research. These targets, whose areal densities cannot be accurately determined by RBS, have been successfully characterized using the joint application of AutoEdge and photolithography-based target fabrication. This innovative approach recently facilitated benchmarking between the NIF and Z experimental platforms. Shot data from these experiments not only substantiated the anomalous increases in x-ray opacity for iron and oxygen under solar convection zone conditions but also contributed significantly to resolving the long-standing solar opacity problem.

Isaac Huegel, *Patricia Cho*, *Heath LeFevre*, *Matthew Trantham*, *Guillaume Loisel* and *Carolyn Kuranz*

Radiation Hydrodynamics Simulations of the Photoionized Expanding Foil Experiment on Z (POSTER PRESENTATION)

ABSTRACT. Accreting black holes in X-ray binaries and active galactic nuclei constitute some of the most luminous objects in the universe. Model fits to reflection spectra from a number of such systems have predicted unreasonably high Fe abundances, inconsistent with predictions from stellar evolutionary theory. This has revealed a need for increased scrutiny of the models. The Z machine at Sandia National Labs has a unique capability to probe the relevant physics. The photoionized expanding foil experimental platform uses the copious X-ray radiation from the Z-pinch to achieve temperature, density, and photoionization conditions found in black hole accretion disks. It provides a means to benchmark astrophysical photoionized plasma codes (such as XSTAR) by measuring high-resolution absorption and emission spectra, which can be used to test the underlying atomic physics in the models. To provide a more thorough interpretation of the data, we have begun using radiation hydrodynamics simulations to address questions of density and temperature gradients, effective mixing of the foil layers, and expansion effects, which can affect the spectroscopic analysis and data-model comparisons. (POSTER PRESENTATION)

Megan Ikeya, *E. Rebeca Toro-Garza*, *Siegfried Glenzer* and *Benjamin Ofori-Okai*

Electrical Conductivity of Warm Dense Nickel Studied by Single-Shot Terahertz Spectroscopy

ABSTRACT. Using intense femtosecond laser pulses one can drive materials to Warm Dense Matter (WDM) conditions. WDM exists at temperatures ~0.1-1eV and densities ~0.1-10g/cc, placing it outside condensed matter or plasma conditions; thus its material properties are hard to predict with either theory. Understanding the properties of WDM is important for many areas of physics including planetary astrophysics and fusion ignition. In particular, the electrical conductivity of WDM is a vital parameter for modeling magnetic fields produced by planetary dynamos [1].

I will present experimental results using terahertz (THz) spectroscopy to measure the electrical conductivity of Warm Dense Nickel (WD-Ni). We use single-shot THz time-domain spectroscopy to measure changes in the THz transmission of nickel heated to the WDM regime. These changes are used to infer the electrical conductivity. THz pulses are ideal probes of conductivity because THz fields oscillate slowly compared to the timescale of electron-electron and electron-ion interactions. In addition, THz pulses provide picosecond resolution and thus can probe transient states of matter. The recent development of single-shot THz detection techniques has enabled THz measurements of materials irreversibly driven to extreme conditions [2, 3]. We observe an approximately four-fold decrease in the electrical conductivity of nickel when heated to the WDM regime. These results are an important first step towards understanding the Earth's dynamo, where nickel is an abundant element.

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Comparison Between Induced Compton Scattering Experiments and Particle-in-Cell Simulation

ABSTRACT. Induced Compton scattering (CS) is a quantum nonlinear interaction between an intense electromagnetic field and a rarefied plasma. Although induced CS is considered to occur in radiation fields with high brightness temperature such as pulsars in nature [1], the principle of induced CS has not been proven experimentally. Therefore, we conducted a proof-of-principle experiment on induced CS using an ultra-intense laser [2] and measured the scattered spectra from the plasma and the laser. As a result, we observed a nonlinear redshift [3], which is considered to be caused by induced CS. We also performed particle-in-cell simulations in which induced CS is not included and found that the experimental results are not explained by classical plasma physics.

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Ou Labun

High Neutron Flux, High Deuteron and Neutron Yields from the Interaction of a Petawatt Laser with a Cryogenic Deuterium Jet

ABSTRACT. A compact high-flux, short-pulse neutron source would have applications from nuclear astrophysics to cancer therapy. Laser-driven neutron sources can achieve fluxes much higher than spallation and reactor neutron sources by reducing the volume and time in which the neutron-producing reactions occur by orders of magnitude. We report progress towards an efficient laser-driven neutron source in experiments with a cryogenic deuterium jet on the Texas Petawatt laser. Neutrons were produced both by laser-accelerated multi-MeV deuterons colliding with Be or mixed metallic catchers and by d(d, n)3He fusion reactions within the jet. We observed deuteron yields of 10^13/shot in quasi-Maxwellian distributions carrying ~ 8 − 10% of the input laser energy. We obtained neutron yields greater than 10^10/shot and found indications of a deuteron-deuteron fusion neutron source with high peak flux (> 10^22 cm^−2 s^−1). The estimated fusion neutron yield in our experiment is one order of magnitude higher than any previous laser-induced dd fusion reaction. Though many technical challenges will have to be overcome to convert this proof-of-principle experiment into a consistent ultra-high flux neutron source, the neutron fluxes achieved here suggest laser-driven neutron sources can support laboratory study of the rapid neutron-capture process, which is otherwise thought to occur only in astrophysical sites such as core-collapse supernova, and binary neutron star mergers. Moving forward, we are preparing an experiment for late 2023 to reproduce the high neutron flux and measure for the first time a multi-neutron capture process with 103Rh and 197Au as nuclear waiting materials.

Heath LeFevre, Julian Kinney, Piper Halcrow, Ryan McClarren, Scott Baalrud and Carolyn Kuranz

Creating Neutron Star Envelope Conditions Using the Omega-60 Laser

ABSTRACT. Neutron stars are generally separated into two regions a thin, partially solid, crust and a liquid, inner core. The crust is about 10% of the star's radius and about 1% of its mass. The behavior of the inner core is an open question. The crust acts as a heat blanket for the star and mediates its cooling, but understanding its behavior provides information about the core. Specifically, there is a relationship between the surface temperature of the star and the temperature at the boundary between the crust and the core, which modeling suggests is isothermal. As one goes deeper into a neutron star crust, the energy transport is radiation dominated before becoming electron dominated in the degenerate material at higher densities. The behavior of the plasma near the transition from radiation dominated to electron dominated heat transport is important for determining the temperature at the crust-core boundary. These high-energy-density conditions have not been explored in transition elements, which are present in neutron star crusts.

This work presents results of capsule implosion experiments at the Omega-60 laser facility that generate radiative shocks in nickel at extreme temperatures and densities. 60 lasers implode a thin shell capsule with an outer layer of plastic and a layer nickel on the interior surface. 1D simulation results suggest that this produces densities greater than 100 g cm-3 and temperatures over 1 keV at average ionization greater than 20. Simulations suggest the conditions in the experiment are near the radiation/electron-dominated conduction boundary in neutron stars with iron-like crusts and surface temperatures near 100 eV. These conditions result in strongly coupled ions with an ion-ion coupling parameter of about 10. The results show spectroscopic measurements and self-emission images of these implosions. The spectroscopic measurements cover the several keV range and capture the k-shell emission from nickel. The self-emission images use molybdenum and nickel filters to only image the emission from the nickel during the implosion.

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Dalton Lund, Eric Lavine, Euan Freeman, Chiatai Chen, Charles Seyler and Bruce Kusse
Dynamics and Stability of Magnetically Driven High Energy Density Plasma Jets on the 1-MA COBRA Generator

ABSTRACT. Astrophysical jets develop over a range of scale lengths and source energies with many having common features that suggest universal mechanisms may be responsible for jet formation and stability. To probe these mechanisms, a novel experiment resembling a planar plasma gun has been developed to produce magnetically driven high-energy-density (HED) plasma jets on the 1 MA, 220 ns rise time COBRA generator. The experimental setup consists of two concentric planar brass electrodes which inject gas directly into vacuum through a central gas line and azimuthally continuous slit. Because there is no ablation phase of a solid target, magnetized jets develop earlier in the current pulse and can be driven longer without depleting their mass source and disrupting. A permanent ring magnet can be housed within the central electrode to provide an initial poloidal magnetic field which links the two electrodes. In this way, the experiment captures the basic dynamics of a central engine-disk system. Specifically, the winding of poloidal field lines due to disk rotation. The resulting free-boundary, high-aspect ratio (>50:1) plasma jets remain stable for hundreds of nanoseconds, achieve lengths >5 cm, and strongly resemble naturally occurring astrophysical jets. Here, we present the design of the experiment and measurements obtained using Thomson scattering, B-dot probes, Faraday rotation, laser interferometry, and self-emission imaging. We demonstrate that jet parameters reasonably scale to their astrophysical counterparts. The experimental results are used to benchmark 3D PERSEUS XMHD simulations with the goal of quantifying the injection and transport of relative canonical helicity.

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Katherine Marrow, Howard Chen, Yiyang Ding, Lee Suttle, Stefano Merlini, Jergus Strucka, Thomas Mundy, Benjamin Duhig and Sergey Lebedev
Radiative Cooling Effects in X-Ray Driven Plasma Jets from Wedge Targets

ABSTRACT. The structure of oblique shocks formed by colliding plasma flows can be influenced by factors such as radiative cooling. Here, we present experiments conducted at the MAGPIE pulsed-power generator (1.4 MA, 240 ns rise time) on colliding plasma flows produced from the ablation of solid targets using a wire array z-pinch as an x-ray source. The experiments use two planar wedge targets placed at an angle to each other such that a jet is formed where the two ablated plasma flows collide. The experiment aims to study the oblique shock where the flow is redirected. In this experiment, the targets are placed outside the return current structure so that there is no background magnetic field from the z pinch. By using different materials for each of the targets (silicon and carbon), we can investigate the effect of radiative cooling on the flow, and how it changes the structure of the shocks at the edges of the jet, as well as the boundary where the two materials collide. We present interferometry and Thomson scattering measurements to characterise this, as well as comparison with simulations using the radiation transport and MHD code Chimera.

Kasper Moczulski, Han Wen, Thomas Campbell, Jack Halliday, Anthony Scopatz, Charlotte A. J. Palmer, Archie F. A. Bott, Charlie D. Arrowsmith, Abel Blazevic, Vincent Bagnoud, Scott Feister, Oliver Karnback, Martin Metternich, Haress Nazary, Paul Neumayer, Adam Reyes, Edward Hansen, Dennis Schumacher, Christopher Spindloe, Subir Sarkar, Anthony R. Bell, Robert Bingham, Francesco Miniati, Alexander A. Schekochihin, Brian Reville, Don Q. Lamb, Gianluca Gregori and Petros Tzeferacos
Numerical Simulations of Laser-Driven Experiments of Ion Acceleration in Stochastic Magnetic Fields

ABSTRACT. The mechanisms by which non-thermal particles are accelerated, commonly observed in solar winds, supernova remnants, and gamma ray bursts, is a topic of intense study. When shocks are present the primary acceleration mechanism is first-order Fermi, which accelerates particles as they cross a shock. While the primary acceleration mechanism for non-thermal particles is first-order Fermi, second-order Fermi acceleration can also contribute, utilizing magnetic mirrors for particle energization. Despite being less efficient, the ubiquitous nature of magnetized turbulence in the universe necessitates the consideration of second order Fermi acceleration. Another acceleration mechanism is the lower-hybrid drift instability, arising from gradients of both density and magnetic field, which produces lower-hybrid waves. The lower-hybrid wave generates an electric field, which if co-propagating with the particle will lead to acceleration. With the combination of high-powered laser systems and particle accelerators it is possible to use magneto-hydrodynamical (MHD) scaling to study the mechanisms behind cosmic ray acceleration in the laboratory. In this work we combine experimental results and high-fidelity three-dimensional simulations to estimate the efficiency of ion acceleration in a weakly magnetized interaction region. We validated the FLASH MHD code with experimental results, using OSIRIS particle-in-cell (PIC) code to verify the initial formation of the interaction region, showing good agreement between codes and experimental results. The study revealed that the plasma conditions in the experiment are conducive to the lower-hybrid drift instability, yielding an increase in energy between 200 keV and 1,200 keV.

Ananya Mohapatra, Abigail Armstrong, Eddie Hansen, Kasper Moculski, Archie Bott, Adam Reyes, Eric Blackman and Petros Tzeferacos
Hall-MHD in Driven Turbulence FLASH Simulations

ABSTRACT. The transport of magnetic flux and energy in collisional, magnetized, high energy density plasma experiments are governed by an extended magnetohydrodynamics (xMHD) ansatz, which includes the Hall-MHD term in the generalized Ohm's law. In this presentation, we discuss the details of the Hall-MHD implementation in the FLASH code, utilizing driven turbulence simulations. FLASH is a publicly available, high-performance computing, multiphysics simulation code, developed by the Flash Center for Computational Science. We investigate the role of the Hall effect in magnetic field generation by studying three-dimensional simulations of the Hall-MHD equations subjected to stochastic drive for a given Mach number. We focus on examining the impact of the Hall effect on the efficiency of the dynamo process across various values of the Hall parameter. By incorporating the Hall effect into the simulations, we explore how it influences the generation and evolution of magnetic fields. Furthermore, we examine energy transfer rates among spatial scales and observe the changes due to the Hall effect in the direct energy cascade at scales relative to the Hall effect. Through detailed analysis, these findings enhance our understanding of the interplay between the Hall effect and magnetohydrodynamics and contribute to the broader knowledge of magnetic field generation and energy transport in high energy density plasmas. The implications of this work extend to various applications, including astrophysics and laboratory plasma experiments, where the Hall effect significantly influences the behavior and dynamics of magnetized systems.

The Flash Center for Computational Science acknowledges support by the U.S DOE NNSA under Awards DE-NA0003856 and DE-NA0003842, DE-NA0004147, DE-NA0004144, and Subcontracts 536203 and 630138 with LANL and B632670 with LLNL. Support from the U.S. DOE ARPA-E under Award DE-AR0001272 and U.S. DOE Office of Science, Fusion Energy Sciences under Award DE-SC0021990 is also acknowledged.

Robert Nowak, Gerrit Bruhaug, Jiacheng Zhao, Yiwen E, Xi-Cheng Zhang, Gilbert Collins and Ryan Rygg

Towards THz Time Domain Spectroscopy on the Omega Laser Facility

ABSTRACT. THz time domain spectroscopy (TDS) measurements of dc conductivity at high energy densities (HED) will help constrain models of planetary interiors, especially planetary dynamos which are necessary to sustain life. Such measurements are within reach at the Laboratory for Laser Energetics thanks to collaborations with the Zhang Terahertz Research Group in the Institute of Optics. It has been shown that THz TDS provides a reliable method to constrain the dc conductivity of materials at extreme conditions [1]. This project develops the experimental design for THz TDS measurements on Omega. Results of a recent, spectrally integrated reflectivity measurement of high intensity THz on Si, carried out on Omega EP, are also presented.

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Stylianos Passalidis, Yuliia Mankovska, Max Gilljohann, Olena Kononenko, Pablo San Miguel Claveria, Ludovic Lecherbourg, Xavier Davoine, Sebastien Corde and Laurent Gremillet

Modelling Electron Deflectometry Measurements of Magnetic Fields in Ultrahigh-Intensity, Femtosecond Laser-Foil Interactions

ABSTRACT. We examine numerically the processes of magnetic field generation in relativistic femtosecond laser-solid interactions. Our study is motivated by a recent experiment at LOA, whereby the B fields induced in a thin (~20 μm) solid foil by a ~1019 Wcm−2, ~30 fs laser pulse were diagnosed via electron deflectometry. In contrast to a previous experiment[1], the ~100 MeV-range probe beam was produced by an auxiliary laser-wakefield accelerator, and injected into the solid foil through its rear (non-irradiated) surface. The mean angular deflection and root-mean-square (rms) spread of the beam electrons after exiting the irradiated foil surface showed nontrivial dependencies on delay time and transverse position with respect to the driving laser pulse. We compare these measurements with the results of 2D collisional particle-in-cell simulations run under conditions as close as possible to the actual ones. Notably, we take into account the 2D preplasma created by the laser's pedestal and describe self-consistently the interaction of the probe electrons with the induced plasma fields. Two main B-field generation mechanisms are found to account for the observed electron deflections: (i) the collisionless current filamentation instability[2], which excites strong (~103 T), kinetic-scale fields around the laser spot[3]; (ii) the fountain-like motion of the fast electrons near the plasma-vacuum boundaries, which leads to azimuthal B fields surrounding the laser spot up to ~100 μm radii[4,5]. Our synthetic deflectometry maps reproduce qualitatively the experimental data as regards both the mean and rms deflections. To shed further light on the simulation results, we proceed with a quasistatic approach which enables the respective effects of the small- and large-scale field components to be isolated as a function of the location and time of probing. Finally, to illuminate the conditions under which these B-field components are generated and evolve, we proceed with a series of plane-wave simulations for laser intensities ranging from 1X1018 Wcm-2 to 5X1020 Wcm-2 under normal or oblique incidence. For increasing laser intensity, we observe an exponential increase in the maximum amplitude reached by both field components during the interaction. The two front-side field components are found to be of comparable magnitude and enhanced at oblique incidence.

P.S. Please not that I am submitting for an oral presentation. There is no section to declare it during submission, so I would like to declare it here.

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(2006). [4] G. Sarri et al., Phys. Rev. Lett. 109, 205002 (2012). [5] W. Schumaker et al., Phys. Rev. Lett. 110, 015003 (2013)

Gonzague Radureau and *Claire Michaut*

New Computational Method for Multigroup Radiative Hydrodynamics Using Artificial Intelligence: Optimisation of the Eddington Factor Calculation

ABSTRACT. Radiative hydrodynamics models the coupling between the dynamics of a hypersonic hot plasma and the radiation it produces or external radiation. Almost every numerical codes use simplified models, that are in most cases either limited or wrong. To accurately model the photon transport the HADES 2D code was specifically developed [2, 3, 4]. Such a code is indispensable for studying astrophysical objects, in which optically intermediate regions are still poorly modeled, yet commonly encountered within such phenomena.

This code couples the hydrodynamics with the M1-multigroup model for radiation transfer [1], to accurately represent the spectral behavior of light, involving the partitioning of the electromagnetic spectrum into groups [5]. Nevertheless, simulating radiative hydrodynamics flows remains highly time-consuming, constraining our capacity to conduct comprehensive numerical studies within this field.

The most expensive part of the M1-multigroup simulations is the calculation of the closure relation, relating the radiative pressure to the radiative energy and the radiative flux, via the Eddington factor. This is due to the lack of an analytical solution. Consequently, two methods exist:

- one accurate yet costly, relying on expensive search algorithms implemented in HADES [4],

- another quicker but incorrect, utilizing the analytical grey case closure relation for each group, implemented in HERACLES [6].

To mitigate these challenges, we've pioneered an inventive approach intertwining neural networks with simplified models. This innovative method dramatically reduces the computation time, while maintaining an acceptable precision, revolutionizing the efficiency of these calculations within M1-multigroup simulations.

To affirm the efficiency of our approach, we conducted validation simulations, beginning with the renowned benchmark simulation of a 1D radiative shock, wherein we used up to five groups. Additionally, we undertook a radial test, to assess the efficiency of our method in a 2D situation. We wish to present this exciting method to the HEDLA conference, through a poster presentation.

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Emily Rettich, *Colin Bruulsema*, *Anna Grassi*, *Frederico Fiuza*, *Wojciech Rozmus* and *George Swadling*

Strong B-Fields Observed in Ion-Weibel Filamented Counter-Streaming Laser-Driven Plasma

ABSTRACT. Laser-driven, counter-streaming plasmas are susceptible to filamentation due to the nonlinear Ion-Weibel instability [1]. Such behavior is hypothesized to be a source of some large magnetic fields in astrophysical plasmas [2]. Experiments conducted on the OMEGA laser facility leveraged novel optical Thomson scattering techniques to measure these filaments and their associated B-fields by examining local intensity fluctuations in ion acoustic waves [2]. This project incorporates analysis of the electron plasma wave (EPW) measurements. The EPW data shows large, rapid fluctuations in plasma density. By measuring the density fluctuations, we can infer the size and growth rate of the filaments.

Additionally, we can leverage our measurements of plasma parameters such as density, temperature, and flow velocity to infer the strength of the B-field in two ways. First, by assuming cylindrical current filaments, allowing us to use Ampere's law to calculate the field [2]. Second, by assuming the thermal pressure in the filaments is balanced by magnetic pressure, with the total pressure only varying in a smooth, non-oscillatory manner. These field estimates, on the order of a hundred Tesla, are then compared to results of 2-D and 3-D PIC simulations.

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Irina Sagert, *Joshua P. Sauppe*, *John L. Kline*, *Kirk A. Flippo*, *Lynn Kot*, *James F. Dowd*, *Thomas H. Day* and *Derek W. Schmidt*

Overview of the Double Cylinder Platform for NIF and Design Efforts

ABSTRACT. The double shell campaign for inertial confinement fusion uses a low-Z ablator and a high-Z inner shell that encloses the deuterium-tritium fuel. During a double shell implosion, the ablator collides with the inner shell, setting it in motion. The inner shell then compresses the fuel to high densities and pressures, enabling volumetric ignition. Due to its high density, the inner shell is prone to the formation of fluid instabilities, particularly on the outer surface of the inner shell, which can significantly degrade capsule performance. Mitigation strategies have been suggested to reduce the growth of instabilities. However, the latter are challenging to image in a spherically converging system, making it potentially non-trivial to quantify whether instability growth is sufficiently suppressed or not. The double cylinder experimental platform is composed of two concentric cylinders to mimic the double shell setup. However, due to their geometry, double cylinders provide the capability to directly measure instability growth by viewing down the cylinder axis, allowing quantification of possible mitigation schemes for fluid instabilities. A key challenge for the double cylinders is ensuring that the inner cylinder stays sufficiently uniform in the axial direction during the implosion for imaging to be effective. Here, we will give an overview of current and future design ideas, and we will present results from recent double cylinder experiments at the National Ignition Facility.

Ruben Santana, Carlos Monton, Haibo Huang, Kevin Sequoia, Neal Tomlin and Michael Farrell
Fabrication of Thick Oxide and Metal Foils for Solar Opacity Motivated High Energy Density Experiments

ABSTRACT. Large-scale High-Energy Density (HED) facilities provide a unique platform for astrophysicists to conduct controlled laboratory experiments, replicating extreme conditions found in white dwarf stars and solar interiors. General Atomics (GA) has been at the forefront of this endeavor, researching and developing cutting-edge material science processes. This involves producing freestanding thick oxide and metal foils with precise areal densities required for experiments at facilities such as the National Ignition Facility (NIF) and the Z Facility. The top two contributors to solar opacity are (1) oxygen (2) iron. The effect of Fe has been extensively studied since 2004 using Fe/Mg comix targets (and contrast against Ni/Mg targets) where GA contributed photolithography-based target production and x-ray transmission-based metrology known as AutoEdge, the effect of oxygen is unknown due to the lack of HED targets with sufficient oxygen areal density. In this work, we have created thick oxide targets to enable the experimental investigation of the oxygen contribution on NIF and Z. Addressing the challenge of obtaining high-density oxygen, we utilize SiO_2 to immobilize a significant amount of oxygen, while using the broadening of Si k-shell emission line as a local plasma condition sensor. Improved plasma condition determination is achieved with Mg k-shell emission lines when MgO is incorporated into SiO_2, either as a discrete layer or in composite form. The high areal density required, typically 3 μm to 6 μm of SiO_2 deposition, leads to high stress buildup, resulting in issues like delamination and cracking. Stress management becomes an integral aspect of our coating design, especially for mixed oxides where the stress build-up is significantly worse. The oxide thickness is one order of magnitude beyond the probing depth of Rutherford Backscattering Spectrometry (RBS) method, necessitating the deployment of AutoEdge which also has the side benefit of being non-destructive. (RBS degrades & destroys the tamping layer made of parylene.) Preliminary data from Z (the ZAPP program at Sandia) and NIF (the Discovery Science program at LLNL) suggest that oxygen contributes anomalously to x-ray opacity under higher HED conditions, which along with iron, contributes significantly to the surplus needed to resolve the solar opacity problem. Through the Sun as a model system for stellar evolution, we gained a deeper understand of the fundamental building block of our universe.

Sarah Shores Prins, Cameron Allen, Laurent Divol, Ryan Enoki, Dirk Gericke, Landon Morrison, Matthew Oliver, Yuan Ping, Nathaniel Schaffer, Markus Schoelmerich, Tilo Doeppner and Thomas White
Measuring the Thermal Conductivity of Iron Alloys Under Planetary Core Conditions at the OMEGA Laser Facility

ABSTRACT. (Abstract submission for poster)

Understanding the thermal conductivity of materials found in the cores of large rocky planets can help us predict planetary evolution and understand the mechanisms necessary for the existence of organic life. However, significant variations in scientific modeling and a scarcity of experimental measurements limit our understanding of materials at these temperatures and pressures. Here we use our isochoric heating platform[1] developed for the OMEGA 60 Laser System to measure the thermal conductivity of iron alloys at planetary interior conditions. By heating a buried 5 μm high-concentration iron alloy wire encased in 10 μm of borosilicate glass to the conditions close to those found in the interiors of large Earth-like planets, we generate an interface that mimics the core-mantle boundary. After pressure equilibration, the shape of the density profile across the interface evolves primarily through thermal conductivity. The profile is measured using diffraction-enhanced X-ray radiography with a spatial resolution on the order of 1 μm[1,2,3], which enables the accurate extraction of the thermal conductivity scale length.

Jaya Sicard, Travis Griffin, Thomas White, Daniel Haden, Bob Nagler, Hae Ja Lee, Eric Galtier, Dimitri Khagani, Sameen Yunus, Eric Cunningham, Jerome Hastings, Jacob Molina, Siegfried Glenzer, Emma Mcbride, Luke Fletcher, Giulio Monaco, Ulf Zastrau, Karen Appel, Sebastian Goede, Lennart Wollenweber, Dirk Gericke, Gianluca Gregori, Carson Convery, Adrien Descamp and Jeremy Iratcabal
Electron-Ion Equilibration Rates in Warm Dense Metals

ABSTRACT. I'd like to present a poster on the following:

When a high-intensity laser beam hits a solid target, preferential and rapid heating of one part over the other results in a highly non-equilibrium state1;2. These temporary, high-energy-density plasmas pave the way for warm dense matter (WDM) and allow us to test quantum mechanical ideas concerning electron-ion interactions in this state. Using a high-resolution (~50meV) X-ray scattering platform3 designed for use with free-electron lasers, we are capable of measuring changes to the quasi-elastic Rayleigh peak. The peak's full-width half max directly reflects the ions' velocity distribution, which correlates to a model-independent ion temperature measurement of the plasma and is determined by Doppler broadening. We have measured the time evolution of the ion temperature over the first ~20ps for a metallic thin films after irradiation, during which the ions are acceleratedly heated to electronvolt temperatures. Using the ion's temperature progression, we are able to determine the electron-ion equilibration rates in the warm dense regime. We investigate the behavior of electron-ion equilibration rates across the solid-liquid phase boundary for gold, and expect to see similar behavior in other metals.

This work was funded in part by the U.S. Department of Energy, National Nuclear Security Administration (NNSA) under Award No. DE-NA0004039. Use of the Linac Coherent Light Source (LCLS), SLAC National Accelerator Laboratory, is supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences under Contract No. DE-AC02-76SF00515. The MEC instrument is supported by the U.S. Department of Energy, Office of Science, Office of Fusion Energy Sciences under contract No. DE-AC02-76SF00515.

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Naoya Tamaki, *Takumi Minami*, *Soichiro Suzuki* and *Yasuhiro Kuramitsu*

Optimization of Ion Acceleration by Irradiating Large-Area Suspended Graphene with an Intense Laser

ABSTRACT. The development of chirped-pulse-amplification (CPA)[1] has made it possible to realize a new type of ion source called laser ion acceleration, where the ions are accelerated by plasma generated when a target irradiated by an intense laser. Laser ion acceleration is a useful method for simulating cosmic ray acceleration in space, and its acceleration mechanism is actively being researched. Furthermore, the ability of laser ion acceleration to miniaturize accelerators is expected to lead to applications in various fields, including medicine and nuclear physics. However, ions with energy levels as high as actual cosmic rays have not yet been generated, and they have not reached the energy levels required for applications. This is the current situation, and the generation of high-energy ions remains a challenge in laser ion acceleration[2]. Generally, as the target thickness decreases, the energy of the accelerated ions increases, but on the other hand, there is a problem that a thin target is easily destroyed by prepulses and pedestals before the laser intensity reaches its peak[3]. To solve this problem, we developed a large-area suspended graphene (LSG) target[4]. LSG is the thinnest target in the world that can be adjusted in thickness with 1 nm accuracy. In addition, it shows very high resistance to laser prepulses and pedestals from previous ion acceleration experiments, where energetic protons and carbons are generated by irradiation of an ultra-intense laser without plasma mirror[5]. Therefore, LSG is considered to be a suitable target for laser ion acceleration. Previous studies have focused on demonstrating ion acceleration by irradiating the thinnest target with an intense laser. In this study, the aim is to optimize laser ion acceleration using LSG. As a means to achieve this, parameters such as the F-number and intensity of the laser, as well as the thickness of LSG, are scanned to increase ion energy through particle-in-cell (PIC) simulation. As a result, optimal parameter conditions for acceleration were identified, leading to the successful generation of highly energetic ions at that condition.

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Matthew Trantham, *Derek Shaeffer*, *Mirielle Wong* and *Carolyn Kuranz*

A Study Using Flash to Evaluate a Collisionless Shock Experiment on Z

ABSTRACT. Collisionless shocks are ubiquitous in many astrophysical systems. While we have a wealth of data from satellite measurements, many questions can best be explored in a laboratory setting. Experiments at the Omega Laser Facility (Shaeffer et al 2017, 2019) demonstrated the creation of a high-Mach-number collisionless shock but were limited to a small, magnetized volume. The Z Machine at Sandia National Laboratories can produce a large, magnetized plasma and fast, laser-driven piston by utilizing an exploding wire array and the Z-Beamlet high-powered laser. This would allow previous experiments to be extended to much larger magnetized volumes, enabling collisionless shocks to evolve over much longer time and length scales and undergo processes like shock reformation. This study shows FLASH simulation results of proposed experiments on The Z Machine to study collisionless shocks. We show the dynamics of a laser-driven piston expanding into a large, magnetized plasma.

Vicente Valenzuela-Villaseca, *Jacob M. Molina*, *Derek B. Schaeffer*, *Sophia Malko*, *Jesse Griff-McMahon*, *Kirill Lezhnin*, *Michael J. Rosenberg*, *Suxing H. Xu*, *Dan Kalantar*, *Clement Trosseille*, *Hye-Sook Park*, *Bruce A. Remington*, *Gennady Fiksel*, *Dmitri Uzdensky*, *Amitava Bhattacharjee* and *Will Fox*

X-Ray Imaging and Electron Temperature Evolution in Laser-Driven Magnetic Reconnection Experiments at the NIF

ABSTRACT. We present results from X-ray imaging of high-aspect-ratio magnetic reconnection experiments driven at the National Ignition Facility. Two parallel, self-magnetized, elongated laser-driven plumes are produced by tiling 40 laser beams. A magnetic reconnection layer is formed by the collision of the plumes. A gated X-ray framing pinhole camera with micro-channel plate (MCP) detector produces multiple images through various filters of the formation and evolution of both the plumes and current sheet. As the diagnostics integrates plasma self-emission along the line of sight, 2-dimensional electron temperature maps ⟨T_e ⟩_Y are constructed by taking the ratio of intensity of these images obtained with different filters. The plumes have a characteristic temperature ⟨T_e ⟩_Y=180±30 eV, 2 ns after the initial laser irradiation and exhibit a slow cooling up to 4 ns. The reconnection layer forms at 3 ns with a temperature ⟨T_e ⟩_Y=280±50 eV as the result of the collision of the plumes. The error bars of the plumes and current sheet temperatures separate at 4 ns, showing the heating of the current sheet from colder inflows. Using a semi-analytical model, we find that the observed heating of the current sheet is produced by electron-ion drag, rather than the conversion of magnetic to kinetic energy, in these experiments.

Timothy Van Hoomissen, Samuel Eisenbach, Derek Mariscal, Robert Dorst, Derek Schaeffer, Alejandro Ortiz, Haiping Zhang, Lucas Rovige, Christoph Niemann, Carmen Constantin and Jessica Pilgram

Transfer Learning Approaches for Analyzing Two-Dimensional Thomson Scattering Spectra from Laser-Produced Plasmas

ABSTRACT. Thomson scattering diagnostics are powerful approaches to obtain reliable, non-intrusive measurements of electron temperature (Te) and density (ne) without assumptions of the plasma state of equilibrium. Current methods for analyzing Thomson scattering spectra, such as the χ2 method, are computationally expensive, hindering real-time Te and ne measurements. We present a new machine learning model to derive Te and ne from Thomson scattering spectra in both the non-collective (α ≪ 1) and collective (α > 1) regimes. The model uses a transfer learning technique by first training a base model with 10,000 synthetic spectral distributions. Then additional hidden layers are added and trained with experimental data. We find that the calculation time of the neural network is faster compared with the Thomson scattering fitting algorithm in the open source PlasmaPy Python package, and we compare their accuracies too.

Jhonnatan Gama Vazquez, Frederico Fiuza, Alexis Marret and Siegfried Glenzer

Simulation Study of Energy Partition and Particle Injection in Magnetized Collisionless Shocks

ABSTRACT. Collisionless shocks are common in astrophysical plasmas and are known to be important for the magnetic field amplification and acceleration of both high energy electrons and protons. While diffusive shock acceleration is well established, particle injection into the nonthermal tail remains an important puzzle. In this work we present the results of large-scale one-dimensional particle-in-cell simulations of magnetized, non-relativistic, collisionless shocks to discuss how the properties of the injected particles depend on the plasma parameters, namely the Alfvénic Mach numbers and the orientation of the ambient magnetic field with respect to the shock normal. Quasi-parallel and quasi-perpendicular shocks are analyzed. We discuss the shock structure and the injection efficiency into a non thermal power-law-like energy tail, finding that quasiparallel shocks with high Mach number are the most efficient. We analyze the dominant modes excited upstream and discuss their role in controlling electron heating and nonthermal particle energization.

Jaela Whitfield, Heath LeFevre, Sallee Klein, Jill Schell and Carolyn Kuranz

Characterizing a Cu X-Ray Source for Photoionization Front Experiments

ABSTRACT. X-ray radiation interacts with matter in a variety of astrophysical systems throughout our Universe including accretion disk phenomena, supernova remnants, and photoionization fronts. The photoionization front plays an essential role in understanding the evolution of the early Universe. A photoionization (PI) front marks the region within a gas or plasma where the process of photoionization predominantly occurs. PI fronts formed as the first stars heated and ionized surrounding gasses. After the Cosmic “Dark Ages”, radiation from the first stars reionized the Universe after hot matter from the Big Bang cooled and recombined. We aim to study the evolution of PI fronts in a scaled laboratory experiment by creating an x-ray source that is incident on a neutral gas. Characterization of the x-ray course is key to understanding the formation and evolution of the PI front. We show preliminary data analysis of x-ray emission from laser-irradiated copper foils conducted using soft x-ray images and DANTE data on Omega-60. This data serves to characterize the most effective driver for future experiments investigating photoionization fronts.

This work is funded by the U.S. Department of Energy NNSA Center of Excellence under cooperative agreement number DE-NA0003869.

Yangyuxin Zou, Kasper Moczulski and Petros Tzeferacos

FLASH Simulations of Laser-Driven Laboratory Astrophysics Experiments to Study Jets in Common-Envelope Evolution of Binary Stars

ABSTRACT. Massive stars are commonly found in binary systems or multiple star systems. When the evolved primary star in a close binary system expands and engulfs its companion, the two stars share a temporary common envelope (CE). CE evolution is a transient yet critical process in binary star evolution and lead to either a merger of the primary core and the companion or the ejection of the shared envelope. Jet feedback from accretion onto the companion during a CE evolution is speculated to affect the orbital evolution and envelope unbinding process. Previous simulations demonstrate that jets are choked quickly after the plunge-in phase and efficiently transfer their

energy to the envelope thereafter, which leads to increased percentage of envelope unbinding [1]. In this study we investigate the dynamical interaction between jets and stellar envelopes and propose a laboratory-scale, laser-driven plasma experiment to mimic the interaction in a controlled environment. The experiment is designed using FLASH, the radiation-magneto-hydrodynamics code developed at the Flash Center for Computational Science. These simulations can inform and reveal in detail the energy transformations and instability development during jet-envelope interactions, guiding future laboratory astrophysics experiments.

The Flash Center acknowledges support by the U.S DOE NNSA under Awards DE NA0004144, DE NA0004147, and Subcontracts 536203 and 630138 with LANL and B632670 with LLNL. Support from the U.S. DOE ARPA E under Award DE AR0001272 and U.S. DOE Office of Science, Fusion Energy Sciences under Award DE SC0021990 is also acknowledged. We acknowledge support from the National Science Foundation under Award PHY 2308844.

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PROGRAM FOR WEDNESDAY, MAY 22ND

Days: ↤ previous day next day ↦ all days ⮂

View: session overview talk overview

06:45-08:00 Session 15: Breakfast

LOCATION: Shula Grill Restaurant

08:00-08:05 Session 16: Announcements

CHAIR: *Local Organizing Committee*
LOCATION: Horizon Grand Ballroom

08:05-09:40 Session 17: Jets

CHAIR: *Hye-Sook Park*
LOCATION: Horizon Grand Ballroom

08:05 *Patrick Hartigan*
Webb Telescope Images and Spectral Data Cubes of Irradiated Interfaces in the Orion Nebula and Shock Waves in Stellar Jets

ABSTRACT. Because it operates throughout the entire near- and mid-infrared spectral regions, the James Webb Space Telescope (JWST) is an ideal facility to use to study warm molecular gas within star-forming regions, including irradiated interfaces and photodissociation regions (PDRs) where molecules form and dissociate behind H-II regions, and behind shock fronts that exist within bow shocks of stellar jets and along the walls of evacuated cavities. The spectrometers on JWST produce data cubes that separate emission lines clearly from the continuum, and in the case of stellar jets, resolve velocity structures spatially within the flow. In this talk I will summarize some of the initial results from the large PDRs4All collaboration to study irradiated interfaces in the Orion Nebula, and PROJECT-J, a focused study of the collimation and excitation properties of a highly-obscured stellar jet. The rich data sets in these studies make it possible to trace the location of dozens of ions, atoms, and molecules and to calculate temperature and density maps using emission line ratios, especially with the complete set of rotational transitions of the H2 molecule now available with JWST. The infrared spectra show how complex hydrocarbons evolve within PDRs , and the mass loss rates inferred from molecular tracers imply that photons with energies < 13.6 eV may still drive enough photoevaporation to affect planet-formation lifetimes. Experiments involving radiation fronts, jets, and shock waves may lead to laboratory analogs of some of these phenomena and a way to test analytical theoretical formalisms.

08:25 *C. D. Arrowsmith*, *P. J. Bilbao*, *F. Miniati*, *P. Simon*, *A. F. A. Bott*, *S. Burger*, *H. Chen*, *F. D. Cruz*, *T. Davenne*, *A. Dyson*, *I. Efthymiopoulos*, *D. H. Froula*, *A. Goillot*, *J. T. Gudmundsson*, *D. Haberberger*, *J. Halliday*, *T. Hodge*, *B. T. Huffman*, *S. Iaquinta*, *B. Reville*, *S. Sarkar*, *A. A. Schekochihin*, *R. Simpson*, *V. Stergiou*, *R. M. G. M. Trines*, *T. Vieu*, *N. Charitonidis*, *L. O. Silva*, *R. Bingham* and *G. Gregori*
Evidence of Suppressed Beam-Plasma Instabilities in a Laboratory Analogue of Blazar-Induced Pair Jets
PRESENTER: *P. J. Bilbao*

ABSTRACT. Here we report on an experimental platform at the HiRadMat facility, within CERN's accelerator complex aimed at recreating a laboratory analogue of ultra-relativistic blazar-induced pair jets propagating into the intergalactic tenuous plasma. A dense electron-positron pair beam is produced by irradiating a target with 440 GeV protons from the Super Proton Synchrotron. The pair yield and plasma extent are orders of magnitude larger than currently achievable at laser facilities, producing for the first time pair plasma conditions necessary for the study of relativistic kinetic plasma instabilities. In our experiment, the pair beams are remarkably stable as they propagate through 1-m of plasma. Linear theory predicts that the growth of kinetic instabilities is strongly suppressed when non-idealized beam conditions are assumed, such as the inclusion of a small transverse temperature, and particle-in-cell simulations suggest that beam divergences of a few percent are enough to significantly suppress the instability. An experimentally inferred growth rate, when scaled to blazar's jets, is comparable to the inverse-Compton cooling time of the pairs on the cosmic microwave background. Given that a cascade of GeV inverse-Compton scattered photons is not observed from blazar's jets, our results imply that such an absence must be the related to the presence of intervening magnetic fields in the intergalactic plasma of primordial origin.

08:45 *Chikang Li*, *Gabriel Rigon*, *Christian Stoeckl*, *Niels Vanderloo*, *Timothy Johnson*, *Hui Li*, *Bruce Remington* and *Bruno Albertazzi*
Exploring Astrophysical Relevant Plasma Jets on High-Energy-Density Laser Facilities
PRESENTER: *Chikang Li*

ABSTRACT. Fast, axially collimated outflows, or "jets", are ubiquitous in astrophysical environments. They flow from most classes of accreting compact objects including young

stellar objects, neutron stars, and stellar mass black holes to supermassive black holes in the centers of galaxies. Such jets provide strong feedback effects to their surroundings, making them primary systems, for example, for understanding general relativity in black hole systems, their impact on galaxy formation as well as the non-thermal component in the overall cosmic energy flow.

Much progress has been made in astronomical observations and theoretical/computational modeling of astrophysical jets. But many fundamental challenges remain, including issues in jet generation, composition, transport, stability, and interactions. During the past decade, laboratory jet experiments have reached a level of maturity and have yielded interesting insights. Complimentary to magnetically driven laboratory jet experiments (e.g., MAGPIE, Caltech), the advent of high-energy-density (HED) laser facilities, such as NOVA, Gekko, LULI, OMEGA, and the NIF, has enabled experiments with kinetic/thermally driven to reproduce certain aspects of plasma jets in laboratory in the regimes directly relevant to astrophysical systems of interest. These laboratory jet experiments offer a unique opportunity of studying jet propagation, stability, and termination processes with in-situ measurements. Several key physical insights underpin the relevance of laboratory experiments for astrophysical jet studies include: first, when plasma dissipative processes such as viscosity and resistivity are insignificant, the nearly ideal plasma conditions are scale-free, allowing scaling studies of laboratory jets to astrophysical scales; second, when the (dimensionless) jet aspect ratio (length/radius) becomes large (> 10) and the jet lifetime is comparable or longer than the dynamic time (such as sound or Alfven wave crossing time), it becomes meaningful to investigate jet stability; and third, when the kinetic, thermal, radiative and magnetic energy components undergo exchanges, this provides valuable information on how to model such processes in astrophysical jets.

In this talk, we will present some of recent experiments by our team on OMEGA facilities, highlight and discuss our understanding of the underlying physics and remaining issues. These experiments have been instrumental in defining the exciting scientific issues that are attainable with laboratory experiments gaining the physical insight into the jet generation, instability, and interactions, scoping out the possible parameter spaces that are unique to be achieved in large HED facility, such as the NIF, and finally enabling the establishment of the physical scaling from laboratory experiments to astrophysical environments.

This work was supported in part by the U.S. Department of Energy NNSA MIT Center-of-Excellence under Contract DENA0003868, the U.S. Department of Energy, Office of Science and NNSA, HEDLP under Contract DE-NA0004129, and NLUF under Contract DE-NA0003938.

09:05 *Gabriel Rigon*, *Christian Stoeckl*, *Timothy M Johnson*, *Joseph Katz*, *Jonathan Peebles* and *Chikang Li*

A Platform for Studies of Radiative Plasma Jets in the Presence of Magnetic Fields at OMEGA

PRESENTER: *Gabriel Rigon*

ABSTRACT. Plasma jets are commonly observed in the universe. They originate from most classes of accreting systems, for instance, star forming systems, accreting neutron stars, and even black holes. The light resulting from their interaction with surrounding interstellar medium and molecular clouds provides important insights about these astrophysical objects and their systems of origin. Despite this wealth of information and sophisticated simulations developed to model these jets, a consensus has yet to be reached to describe them in their entirety. In particular, their high collimation and apparent stability continue to be subjects for debate. To better understand these objects and to validate the simulated results, plasma jets were produced at OMEGA 60 laser facility in a controlled environment.

In this experimental campaign, laser beams were employed to ablate the inner surface of a half-sphere target. The expanding plasma plumes collided at the center of the half-sphere, resulting in the formation of a cylindrical jet. These jets had a high velocity nearing 1500 km/s and a large aspect ratio (~34) making them relevant for studies of young stellar objects. Various radiative and magnetic conditions were studied by varying the material of the target (low and high atomic number) and by imposing an external magnetic field with a MIFEDS. In this presentation, the results of this experiment, obtained from a set of diagnostics, will be compared to FLASH4 magnetohydrodynamic simulations.

This work was supported in part by the U.S. DOE, LLE and NLUF.

09:25 *Marin Fontaine*, *Clotilde Busschaert*, *Bruno Albertazzi*, *Michel Koenig* and *Emeric Falize*

Experimental and Numerical Studies of Compressions of Dense Clouds Induced by Herbig-Haro Stellar Jets

PRESENTER: *Marin Fontaine*

ABSTRACT. Of all the astrophysical outflows emmited from objects, Herbig-Haro (HH) stellar jets are among the most energetic (Bally 2016). The recent development of laboratory astrophysics using high-power laser facilities makes it possible to study such astrophysical phenomena in the laboratory (Foster et al. 2005). In this work we investigate the role these Herbig-Haro jets play in triggering new star formations in dense media. To do so, a high-energy-density experiment was performed at the LULI2000 laser facility. A plastic ball was compressed by a fast titanium jet produced with a nanosecond laser. In addition, simulations were made on the 3D radiative hydrodynamics code TROLL (CEA-DAM) for a greater detail analysis of the ball compression and the jet characteristics. Using scaling laws, we discuss the similarity between the stellar, the experiment and the numerical jets. Simulations of the

diagnostics (radiative emissions, X-ray and density gradient) were also performed. The agreement between the experiment and the 3D simulation has enabled an in-depth numerical study of the propagation of the jet in media of different densities, or of the deflection of the jet in the case of an off-axis impact with the ball.

09:40-10:10 Coffee Break

10:10-11:40 Session 18: High Power Lasers

CHAIR: *Farhat Beg*
LOCATION: Horizon Grand Ballroom

10:10 *Julien Fuchs*

Generation of Faster Magnetized Shocks to Investigate Drift-Shock Particle Acceleration in the Laboratory

ABSTRACT. The acceleration of energetic charged particles by collisionless shock waves is an ubiquitous phenomenon in astrophysical environment. By coupling high-power lasers with strong magnetic fields, we have been able to generate and characterize magnetized collisionless shocks [1]. Further, we showed that these could accelerate particles in the shock-surfing (SSA) governed, non-relativistic regime [2]. We will here review recent results obtained at the Vulcan TAW laser facility, in which we used higher-energy lasers to generate faster shocks. This, coupled to a shock-shock collision scheme that allows to exploit a phase-locking acceleration mechanism [3,4], allowed us to accelerate particles to higher energy, in a regime which simulations suggest is drift-shock acceleration (DSA). We will also discuss the potential of multi-PW lasers, e.g. Apollon (France) [5] or ELI (Czech Rep., Romania), to generate near- relativistic shocks in the laboratory, by producing a fast enough piston driven into a magnetized ambient plasma.

[1] W. Yao, et al. “Detailed characterization of laboratory magnetized super-critical collisionless shock and of the associated proton energization”, Matter and Radiation at Extremes 7, 014402 (2022) [2] W. Yao, et al. "Laboratory evidence for proton energization by collisionless shock surfing". Nature Physics, 17(10):1177–1182, 2021. [3] W. Yao, et al., “Investigating particle acceleration dynamics in interpenetrating magnetized collisionless super-critical shocks”. Journal of Plasma Physics 89(1), 915890101 (2023) [4] A. Fazzini et al., “Particle energization in colliding subcritical collisionless shocks investigated in the laboratory”, A&A 665, A87 (2022) [5] K. Burdonov et al. “Characterization and performance of the Apollon Short-Focal-Area facility following its commissioning at 1 PW level”, Matter and Radiation at Extremes 6 (2021)

10:30 *Brandon K. Russell*, *Paul T. Campbell*, *Qian Qian*, *Jason A. Cardarelli*, *Christopher Arran*, *Thomas G. Blackburn*, *Stepan S. Bulanov*, *Sergei V. Bulanov*, *Gabriele M. Grittani*, *Stuart P.D. Mangles*, *Christopher P. Ridgers*, *Daniel Seipt*, *Louise Willingale* and *Alexander G.R. Thomas*

Prospects for Laboratory Astrophysics at Multi-Petawatt Laser Facilities

PRESENTER: *Brandon K. Russell*

ABSTRACT. Several multi-petawatt laser facilities are coming online around the world including ZEUS at the University of Michigan and ELI-Beamlines in the Czech Republic that will push forward the energetic frontier of plasma physics with expected laser intensities exceeding 10^23 W/cm^2. One of the most exciting applications of the laser systems at these facilities will be to the study of extreme astrophysical processes. Standard laboratory astrophysics configurations, for example two-beam magnetic reconnection, performed on these facilities will see much stronger fields than has previously been demonstrated. Diagnosing the experiments performed in this regime will be challenging and will likely require novel measurement techniques. In addition, the interactions will be so energetic that strong-field quantum electrodynamics (SFQED) processes including non-linear Compton scattering and non-linear Breit-Wheeler pair creation will become important to the dynamics of the interactions. These SFQED processes are not only important to laser-plasma interactions but appear in the simulations and models used by the extreme astrophysics community for various astrophysical systems including pulsars and magnetars. The validation of models used for these processes is one of the primary goals of these multi-petawatt facilities and will therefore form another area for the plasma physics community to connect with the astrophysics community. In this talk I will discuss work that I have performed to build toward laboratory astrophysics on multi-petawatt laser facilities and my outlook on what these facilities will allow us to study.

This work was supported by the National Science Foundation (NSF Award No. 1751462) and Czech Science Foundation (NSF-GACR collaborative Grant No. 2206059 and NSF Grant No. 2108075). The OSIRIS Consortium (UCLA and IST) provided access to the OSIRIS 4.0 framework (NSF ACI-1339893).

10:50 *Akira Mizuta*, *Shutaro Kurochi*, *Kentaro Sakai*, *Naofumi Ohnishi*, *Chun-Sung Jao*, *Yen-Chen Chen*, *Yao-Li Liu*, *Takeo Hoshi*, *Yuma Terachi*, *Akito Nakano* and *Yasuhiro Kuramitsu*

Numerical Analysis of the Evolution of Kelvin Helmholtz Instabilities and Vortices Generation Associated with Collisionless Shock Experiments

PRESENTER: *Akira Mizuta*

ABSTRACT. We investigate the growth of Kelvin–Helmholtz instability (KHI) and the emergence of vortices in laser produced plasmas through numerical simulations. By irradiating two flat targets, placed at a slight distance from each other, with intense lasers, supersonic plasma from the rear side of each target is generated, leading to counter-streaming flows between the targets. The collision of these flows results in the observation of filamentary structures via proton backlight imaging, indicating the excitation of electric and/or magnetic fields within the shock-compressed plasma. We have done radiation hydrodynamic simulations and high-resolution hydrodynamic simulations to analyze our experimental setup. We observed the growth of KHI at the contact discontinuities, attributed to the curved contact discontinuity and shear flows. This instability growth induces turbulence in the shocked plasma and the excitation of electric and/or magnetic fields. We have been implementing data science and machine learning to reconstruct the vector three-dimensional turbulent electromagnetic fields.

11:10 *Luca Orusa*, *Damiano Caprioli*, *Anatoly Spitkovsky* and *Lorenzo Sironi*
Particle Acceleration in 3D Simulations of Quasi-Perpendicular Shocks
PRESENTER: *Luca Orusa*

ABSTRACT. Understanding the conditions conducive to particle acceleration at collisionless, non-relativistic shocks is important for the origin of cosmic rays. We use hybrid (kinetic ions—fluid electrons) and full particle-in-cell kinetic simulations to investigate particle acceleration and magnetic field amplification at non-relativistic, weakly magnetized, quasi-perpendicular shocks. So far, no self-consistent kinetic simulation has reported non-thermal tails at quasi-perpendicular shocks. Unlike 2D simulations, 3D runs show that protons develop a non-thermal tail spontaneously (i.e., from the thermal bath and without pre-existing magnetic turbulence). They are rapidly accelerated via shock drift acceleration up to a maximum energy determined by their escape upstream. We discuss the implications of our results for the phenomenology of heliospheric shocks, supernova remnants and radio supernovae.

11:22 *Kirill Lezhnin*, *Samuel Totorica* and *Will Fox*
PIC Simulations of Expanding HED Plasmas with Laser Ray Tracing
PRESENTER: *Kirill Lezhnin*

ABSTRACT. Design and analysis of high energy density (HED) experiments utilizing high power lasers usually rely on radiation hydrodynamics simulations. There are some laser-plasma interaction regimes, however, where plasma possesses long mean-free-path properties, such as magnetic field generation via the Biermann battery mechanism, strongly driven magnetic reconnection, or formation of magnetized collisionless shocks via ablated plume-ambient plasma interaction. Thus, first-principle kinetic simulations or extended fluid models may be necessary for better understanding of the HED physics. In our work, we present the benchmarking and the first results obtained with laser energy deposition module implemented in the particle-in-cell code PSC. The simulation results are tested against the radiation hydrodynamic simulations with the FLASH code and analytical estimates. We also discuss possible kinetic effects that are to be expected from laser target ablation in the HED regime.

12:00-13:30 Lunch Break

13:30-15:00 Session 19: Transport Properties and Spectroscopy

CHAIR: *Tobias Dornheim*
LOCATION: Horizon Grand Ballroom

13:30 *Sam Vinko*
Resonant Inelastic X-Ray Scattering in Warm-Dense Fe Compounds

ABSTRACT. Resonant inelastic x-ray scattering (RIXS) is a powerful spectroscopic technique capable of providing direct access to the electronic structure (and dynamics) of atoms, molecules, and solids. However, RIXS is a photon hungry technique that requires access to an energetic and highly monochromatic x-ray source. To date, these requirements have hindered its application to the study of matter at extreme conditions, including matter driven by laser shock compression, which, in turn, has limited our ability to study the evolution of electronic structure in matter at high density. Here I will discuss how high-resolution RIXS measurements can be enabled by using the stochastic nature of the full self-amplified spontaneous emission FEL pulse via a newly developed dynamic kernel deconvolution method with a neural surrogate. Using this approach, we can discriminate between the valence electronic structures of Fe in pure Fe and in Fe_2O_3, and measure the temperature in warm-dense Fe compounds via the M-shell ionization signature in RIXS directly.

13:50 *Cameron Allen*, *Matthew Oliver*, *Dirk Gericke*, *Laurent Divol*, *Gregory Kemp*, *Otto Landen*, *Landon Morrison*, *Yuan Ping*, *Markus Schoelmerich*, *Sarah Shores*, *Wolfgang Theobald*, *Tilo Doeppner* and *Thomas White*
Experimentally Measuring Thermal Conductivity in Warm Dense Matter
PRESENTER: *Cameron Allen*

ABSTRACT. Heat transport throughout high-energy-density systems and across interfaces is an important process with many unresolved aspects. In particular, thermal conductivity in warm dense matter has extensive theoretical predictions but lacks experimental benchmarking [1]. We use Fresnel Diffractive Radiography [2-4] to measure the interface evolution in an isochorically-heated plastic-coated tungsten wire. After pressure equilibration, the interface is hydrodynamically stable and its evolution is driven primarily through thermal conduction, which modifies the temperature and density profiles. We find experimental evidence of a significant, enduring heat barrier between the warm dense tungsten and its surrounding plastic. This temperature jump is characteristically similar to temperature jumps resulting from interfacial thermal resistance [5], indicating that the phenomenon can play a significant role at these extreme conditions. The restricted heat flow may be of particular importance for inertial confinement fusion experiments, where instability-prone material interfaces play a large role in determining capsule implosion performance [6]. [1] T. G. White et al. Phil. Trans. Roy. Soc. A 381, 20220223 (2023). [2] C. H. Allen et al. Appl. Opt. 61, 1987 (2022). [3] M. Oliver et al. Rev. Sci. Inst. 93, 093502 (2022). [4] M. O. Schoelmerich et al. Rev. Sci. Inst. 94, 013104 (2023). [5] J. Chen et al. Rev. Mod. Phys. 94, 025002 (2022). [6] B. Hammel et al. High Ener. Dens. Phys. 6, 2, 171 (2010)

14:10 *Nitish Acharya*, *Hadley Pantell*, *Danae Polsin*, *Ryan Rygg*, *Gilbert Collins*, *Peter Celliers*, *Hussein Aluie* and *Jessica Shang*
Measuring Viscosity at High Pressures and Temperatures Using Shock-Wave Perturbation Decay
PRESENTER: *Nitish Acharya*

ABSTRACT. Determining transport properties like viscosity under extreme conditions remains challenging, yet critical for applications like inertial confinement fusion and modeling planetary interiors. We present a new experimental implementation to infer viscosity at extreme pressures and temperatures by leveraging rippled shock waves in laser-driven experiments. The experiments utilize OMEGA EP beams to drive a multi-megabar shock into a fused silica target with pre-imposed sinusoidal interface modulations. This perturbation is transferred to the shock front, initiating damped oscillatory motion. We demonstrate that a combination of line-imaging velocity interferometry and streaked optical pyrometry enables measurements of continuous temporal evolution of the rippled shock from a single laser shot. We also compare the measurements with two-dimensional hydrodynamic simulations which qualitatively reproduce the observed dynamics and provide insights into the experiment's hydrodynamics. Further quantitative analysis based on analytical rippled shock theory will allow determining viscosity of shock-compressed material.

14:30 *Travis Griffin*, *Daniel Haden*, *Thomas White*, *Bob Nagler*, *Hae Ja Lee*, *Eric Galtier*, *Dimitri Khaghani*, *Sameen Yunus*, *Eric Cunningham*, *Jerome Hastings*, *Jacob Molina*, *Siegfried Glenzer*, *Emma McBride*, *Luke Fletcher*, *Giulio Monaco*, *Ulf Zastrau*, *Karen Appel*, *Sebastian Goede*, *Lennart Wollenweber*, *Dirk Gericke*, *Gianluca Gregori*, *Ben Armentrout*, *Carson Convery* and *Adrien Descamp*
Validation of Electronic Bond Hardening in Thin Gold Films
PRESENTER: *Travis Griffin*

ABSTRACT. I would like to submit this abstract for an oral presentation.

When a high-intensity laser is incident on a solid target, the preferential and rapid heating of electrons over the ions creates a highly non-equilibrium state. These highly transient, high-energy-density plasmas are a precursor to equilibrated warm dense matter (WDM). We have developed a high-resolution (~50 meV) X-ray scattering platform to be used with free-electron lasers that is capable of measuring changes to the quasi-elastic Rayleigh peak. Governed by Doppler broadening, the peak’s width corresponds to a direct measurement of the ions’ velocity distribution. This acts as a model-independent ion temperature measurement for the plasma. Combining this temperature measurement with the Bragg peak diffraction allows us to use the Debye-Waller relationships to uniquely determine the Debye temperature and ultimately the inter-atomic bond strength of the thin metallic samples.

14:42 *Kelin Kurzer-Ogul*, *Brian Haines*, *David Montgomery*, *Silvia Pandolfi*, *Andrew Leong*, *Arianna Gleason*, *Hussein Aluie* and *Jessica Shang*
Transport Properties in HED Shock-Bubble Interactions
PRESENTER: *Kelin Kurzer-Ogul*

ABSTRACT. Shock-bubble interactions occur in a wide range of astrophysical flows and can be studied directly in scaled laboratory experiments. We present new simulation results using the xRAGE radiation-hydrodynamic code which examine the role of heat and radiation transport in high energy density (HED) void collapse experiments performed at SLAC National Accelerator Laboratory. The experiments and simulations involved a 300-400 GPa shock generated by laser ablation of a polystyrene-like target containing an artificial void. We show that our simulations are largely insensitive to radiation model, indicating that radiation transport does not yet play an important role at “low” HED pressures. We also show that the dominant effect of heat conduction on experimental observables is to alter the properties of secondary shocks that reverberate between the ablation front, sharp impedance gradients, and the primary shock front. In particular, we show that this relationship is simple and monotonic. These results suggest that it may be possible to infer transport properties such as heat conductivity from shock characteristics that are measurable by direct imaging in these experiments.

15:00-15:30 Coffee Break

15:30-17:00 Session 20: High Power Laser Experiments and Turbulence

CHAIR: *Julien Fuchs*
LOCATION: Horizon Grand Ballroom

15:30 *Mamiko Nishiuchi*, *Chang Liu*, *Masayasu Hata*, *Nicholas Peter Dover*, *Kotaro Kondo*, *Akira Kon*, *Hironao Sakaki*, *Hiromitsu Kiriyama*, *James Kevin Koga*, *Tatsuhiko Miyatake*, *Haruya Matsumoto*, *Nuo Xu*, *Ginevra Casati*, *Zulfikar Najmudin*, *Marvin Paul Umlandt*, *Milenko*

Vescovi-Pinochet, Pengjie Wang, Tim Ziegler, Ulrich Schramm, Karl Zeil, Natsumi Iwata and Yasuhiko Sentoku
Dynamics of Plasma Formation and Highly Charged Au Ion Acceleration Driven by High-Intensity, High-Contrast Laser Pulse
PRESENTER: Mamiko Nishiuchi

ABSTRACT. The high intensity high contrast short pulse laser is a unique tool for generation of the high temperature (~ 10 keV) solid density highly charged plasma in an extreme condition. The understanding the dynamics and ionization physics of the plasma is very important because the plasmas provide a platform for transforming electromagnetic laser fields into quasi-electrostatic fields for the high energy particle accelerations. For high efficient acceleration of the charged particles, obtaining highly charged ion states is crucial. However, the way to achieve the condition is not simple because the ionization physics is strongly related to the dynamics of the non-LTE plasma which is rapidly heated up within a femtosecond time scale. In our previous study, we clarified experimentally/theoretically/computationally the transition of dynamics and ionization mechanism of the silver (Z=47) plasma depending on the target thickness formed by the 5x1021 Wcm-2, 12 J, 45 fs laser pulses with relatively good intrinsic contrast condition. For the optically thick target case, the collisional ionized silver ions in a resistively heated up to ~ 10keV plasma are accelerated by the sheath field at the back side of the target (Au+40 13MeV/u), while in the optically thin plasma the laser field ionized silver ions are accelerated by Hole boring mechanism at the front side of the target and sheath field at the back side of the targets (Au+45, 25 MeV/u). We recently extend the study of the dynamics and ionization mechanisms to heavier ion plasms, such as gold (Z=79) with 3x1021 Wcm-2, 10 J, 45 fs, plasma mirror cleaned laser pulses. The purpose of using plasma mirror cleaned laser pulse is to inject the laser energy in the gold plasma before the plasma cools down by radiation. We simultaneously invent X-ray diagnostic for the temperature measurement. For the optically thick target, the observed temperature of ~ 10 keV level is consistent with the PIC simulation and the analytical calculation by assuming that the plasma is resistively heated up. The average charge states of gold plasmas estimated by the shift of the spectral lines (corresponds to M to L shells transitions) with the help of atomic code GRASP reasonably matches to the observed temperature. We have demonstrated that a short pulse high intensity laser can heat up high-Z targets to extreme conditions by controlling the laser pulse temporal profile. The comprehensive understanding of laser-driven heavy ion acceleration dynamics paves the way to controlling the production of highly charged high-energy heavy-ion beams with PW class high-intensity short-pulse lasers. The ability to accelerate high charge state heavy ions over such small spatial and temporal scales is a significant step toward the realization of a next-generation compact heavy-ion accelerator, enabling exploration at the frontier of nuclear physics and nuclear astrophysics.

15:50 Gerrit Bruhaug, Ellie Tubman, Matthew Selwood, Matthew Freeman, Christopher Walsh, Hans Rinderknecht, James Rygg, Gilbert Collins and Jessica Shaw
Relativistic Electron Radiography of Laser Driven Foils
PRESENTER: Gerrit Bruhaug

ABSTRACT. Laser-plasma electron accelerators using the already available ps lasers at HED facilities [1] provide a new method of charged particle radiography of HED conditions [2]. Relativistic electrons are far more penetrating than laser-generated protons and provide contrasting electric and magnetic field measurements. This is crucial for measuring fields in high-Z conditions of interest, such as hohlraums [3]. The <1 ps probe time of the electrons also allows for very precise probing of specific times of HED conditions. This talk will report measurements of fields in laser driven foils with pulse lengths ranging from 0.1-2.5 ns and foil materials ranging from plastic to gold. These results provide insight into the expansion of laser-driven plasmas in hohlraum relevant conditions as well as insight into the laser-plasma accelerator itself.

1)J. L. Shaw et al., “Microcoulomb (0.7 ± 0.40.2 μC) laser plasma accelerator on OMEGA EP,” Scientific Reports, vol. 11, no. 1, pp. 1–9, 2021.

2)Bruhaug, G., Freeman, M.S., Rinderknecht, H.G. et al. Single-shot electron radiography using a laser–plasma accelerator. Sci Rep 13, 2227 (2023).

3)C. A. Walsh, J. D. Sadler, and J. R. Davies, “Updated magnetized transport coefficients: Impact on laser-plasmas with self-generated or applied magnetic fields,” Nuclear Fusion, vol. 61, no. 11, 2021.

16:10 Daisuke Tanaka, Hiroshi Sawada, Koki Kawasaki, Toshihiro Somekawa, Toshinori Yabuuchi, Kohei Miyanishi, Keiichi Sueda, Yuichi Inubushi, Tomohiro Shimizu, Shoso Shingubara, Kohei Yamanoi and Keisuke Shigemori
Study on Energy Transport in Laser-Irradiated Nanowire Arrays for Creating Ultra-High Energy Density States with X-Ray Free Electron Laser, SACLA
PRESENTER: Daisuke Tanaka

ABSTRACT. Nanowire (NW) arrays are of wires with a few hundred nm in diameter and 2-10 μm in length aligned vertically on a bulk surface. is a promising nano-structured target for laser-plasma experiment. A previous study shows that nanowire array targets can absorb a higher laser energy than a flat foil target, efficiently creating volumetric ultra-high energy density states [1,2], which is of astrophysical interests. However, energy absorption and transport mechanisms in the laser-NW array interaction are still unclear. Here, we report an experiment on SACLA x-ray free electron laser (XFEL) facility to evaluate the energy

absorption and transport in the nanowire arrays. The NW arrays we used in this experiment were fabricated by AAO template method. Cu wires with 2 μm lengths were grown on a 10 μm thick Cu substrate. The wire diameter and the density of the NW array were 200-300 nm and 16%, respectively. As a reference target, we employed 10-μm thickness Cu foils. The NW arrays and solid targets irradiated with an ultrahigh-intensity laser were probed with an XFEL beam with a photon energy of 8.92 keV for x-ray transmission imaging [3]. We observed temporal evolution of the heated region in the NW array by changing the delay time of the ultra high-intensity laser and the XFEL. The optical laser at a wavelength of 800 nm produced a 30 fs pulse with a 0.8 J beam energy in 15-20 μm spot diameter (FWHM). Fast electrons and electron-induced x-rays were measured with an electron spectrometer, an Bragg crystal spectrometer and a Cu Kα imager. Details of the measurements and interpretation of the data will be discussed.

16:22 *Kentaro Sakai*, *Kosuke Himeno*, *Kiyochika Kuramoto*, *Shuta Tanaka*, *Tatiana Pikuz*, *Takafumi Asai*, *Yuki Abe*, *Takumi Minami*, *Fuka Nikaido*, *Toshiharu Yasui*, *Hideki Kohri*, *Masato Kanasaki*, *Reona Ozaki*, *Keita Toyonaga*, *Hajime Maekawa*, *Hiromitsu Kiriyama*, *Akira Kon*, *Kotaro Kondo*, *Nobuhiko Nakanii*, *Wei-Yen Woon*, *Che-Men Chu*, *Kuan-Ting Wu*, *Chun-Sung Jao*, *Yao-Li Liu*, *Shogo Isayama*, *Atsushi Tokiyasu*, *Harihara Sudhan Kumar*, *Kentaro Tomita*, *Yuji Fukuda* and *Yasuhiro Kuramitsu*

Plasma Structure and Magnetic Field Measurements with Scattered Intense Laser Beam

PRESENTER: *Kentaro Sakai*

ABSTRACT. Short-pulse intense lasers have potentials to model extreme astrophysical environments in laboratories. Although ex-situ measurements of distribution functions using electron spectrometer and Thomson parabola are standard diagnostics in the intense laser experiments, the diagnostics to measure the interaction region of laser and plasma are limited. We have been developing the diagnostics of the interaction between intense laser and plasma using scattered intense laser. We performed experiments to observe the spatial distributions and spectra of the scattered main laser beam interacting with gas-like target using optical imaging and spatially resolved spectrometer, respectively. The observed light has a polarization that is consistent with the main laser beam indicating the observed light originates from the main laser. The image reflects the spatial distribution of electron and focusing laser beam. The spectrum has a periodic structure in the wavelength. Comparing the results with numerical simulations, the periodic structure can be the Bernstein wave resonant feature and one can estimate magnetic field from the periodic spectrum.

16:34 *Seth Davidovits*, *David C. Collins*, *Saee Dhawalikar*, *Christoph Federrath*, *Luz Jimenez Vela*, *Mario Manuel* and *Sabrina R. Nagel*

NIF Experiments on the Driving Parameter of Shock-Forced Turbulence for Star Formation

PRESENTER: *Seth Davidovits*

ABSTRACT. Stars form in turbulent clouds of molecular hydrogen, where shocks in the compressible turbulence drive local density enhancements that can lead to local gravitational decoupling from the cloud and star formation. Key star formation metrics, such as the star formation rate or the mass distribution of the resulting stellar population, are therefore tied to the density distribution of the turbulence. This density distribution, in turn, is sensitive to the way the turbulence is driven, where a turbulent driving parameter links the density variance to the level of turbulence as measured by the turbulent Mach number. Here we describe progress on experiments to infer the turbulent driving parameter for turbulence forced by shocks, as is often the case for star forming clouds. Compressible turbulence is generated in a shock tube at the National Ignition Facility (NIF) by sending a shock through a foam with pre-fabricated density non-uniformity. Radiography and line-imaging VISAR, along with secondary diagnostics, are used to diagnose the experiments. An initial analysis of the experiments infers the shock-forced turbulence has a highly compressive driving parameter.

This work was performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract No. DE-AC52-07NA27344.

19:00-21:00 Banquet Dinner

LOCATION: Horizon Grand Ballroom

19:45-20:30 Session 21: Banquet Dinner Speech

banquet talk

LOCATION: Horizon Grand Ballroom

19:45 *Daniel Casey*

ICF, Rampant Instabilities at >500 Gbar, and yet It Burns

PROGRAM FOR THURSDAY, MAY 23RD

Days: ↤ previous day next day ↦ all days

View: session overview talk overview

06:45-08:00 Session 22: Breakfast

LOCATION: Shula Grill Restaurant

08:00-08:05 Session 23: Announcements

CHAIR: *Local Organizing Committee*
LOCATION: Horizon Grand Ballroom

08:05-09:40 Session 24: MHD Instabilities and Reconnection

CHAIR: *Mikhail Medvedev*
LOCATION: Horizon Grand Ballroom

08:05 *Hantao Ji*, *Lan Gao*, *Geoff Pomraning*, *Kentaro Sakai* and *Fan Guo*
Study of Electron Acceleration and Ion Acoustic Waves During Low-Beta Magnetic Reconnection Using Laser-Powered Capacitor Coils
PRESENTER: *Hantao Ji*

ABSTRACT. Magnetic reconnection is a ubiquitous fundamental process in space and astrophysical plasmas that rapidly converts magnetic energy into some combination of flow energy, thermal energy, and non-thermal energetic particles. Over the past decade, a new experimental platform has been developed [1] to study magnetic reconnection using strong coil currents powered by high power lasers at low plasma beta, typical conditions under which reconnection is energetically important in astrophysics. KJ-class lasers were used to drive parallel currents to reconnect MG-level magnetic fields in a quasi-axisymmetric geometry, similar to the Magnetic Reconnection Experiment or MRX [2], and thus this platform is named micro-MRX. This presentation summarizes two major findings from micro-MRX: direct measurement of accelerated electrons [3] and observation of ion acoustic waves [4] during anti-parallel reconnection. The angular dependence of the measured electron energy spectrum and the resulting accelerated energies, supported by particle-in-cell simulations, indicate that direct acceleration by the out-of-plane reconnection electric field is at work. Furthermore, a sudden onset of ion acoustic bursts has been measured by collective Thomson scattering in the exhaust of magnetic reconnection, followed by electron acoustic bursts with electron heating and bulk acceleration. These results demonstrate that the micro-MRX platform offers a novel and unique approach to study magnetic reconnection in the laboratory beyond the capabilities provided by traditional magnetized plasma experiments such as MRX and the upcoming FLARE or (Facility for Laboratory Reconnection experiments) [5]. Implications of these laboratory findings to astrophysical scenarios and future work on studying other particle acceleration mechanisms and ion acoustic waves during magnetic reconnection are discussed.

[1] L. Gao, H. Ji, G. Fiksel, W. Fox et al., “Ultrafast proton radiography of the magnetic fields generation by laser-driven coil currents,” Physis of Plasma 23, 043106 (2016) [2] M. Yamada, H. Ji, S. Hsu, T. Carter et al., “Study of driven magnetic reconnection in a laboratory plasma,” Physis of Plasmas 4, 1936-1944 (1997) [3] A. Chien, L. Gao, S. Zhang, H. Ji et al., “Non-thermal electron acceleration from magnetically driven reconnection in a laboratory plasma,” Nature Physis 19, 254-262 (2023) [4] S. Zhang, A. Chien, L. Gao, H. Ji et al., “Ion and electron acoustic bursts during anti-parallel magnetic reconnection driven by lasers,” Nature Physis 19, 909-916 (2023) [5] H. Ji, W. Daughton, J. Jara-Almonte, A. Le, A. Stanier, and J. Yoo, “Magnetic reconnection in the era of exascale computing and multiscale experiments,” Nature Reviews Physics 4, 263-282(2022)

08:25 *Jacob Pearcy*, *Michael Rosenberg*, *Timothy Johnson*, *Graeme Sutcliffe*, *Benjamin Reichelt*, *Jack Hare*, *Nuno Loureiro*, *Richard Petrasso* and *Chikang Li*
Experimental Evidence of Plasmoids in High-β Magnetic Reconnection
PRESENTER: *Jacob Pearcy*

ABSTRACT. Magnetic reconnection is a ubiquitous and fundamental process in plasmas by which magnetic fields change their topology and release magnetic energy. Despite decades of research, the physics governing the reconnection process in many parameter regimes remains controversial. Contemporary reconnection theories predict that long, narrow current sheets are susceptible to the tearing instability and split into isolated magnetic islands (or plasmoids), resulting in an enhanced reconnection rate. While several experimental observations of plasmoids in the regime of low-to-intermediate β (where β is the ratio of plasma thermal pressure to magnetic pressure) have been made, there is a relative lack of experimental evidence for plasmoids in the high-β reconnection environments which are typical in many space and astrophysical contexts. Here, we report strong experimental evidence for plasmoid formation in laser-driven high-β reconnection experiments.

08:45 Yasuhiro Kuramitsu, Kentaro Sakai, Toseo Moritaka, Taiki Jikei, Takanobu Amano, Yosuke Matsumoto, Chun-Sung Jao, Yen-Chen Chen, Fuka Nikaido, Yao-Li Liu, Takumi Minami, Shogo Isayama, Yuki Abe, Naofumi Ohnishi, Akira Mizuta, Yuma Terachi, Akito Nakano, Takeo Hoshi, Naoya Tamaki, Shutaro Kurochi, Che-Men Chu, Wei-Yen Woon, Masato Kanasaki, Satoshi Kodaira, Yuji Fukuda, Bruno Albertazzi and Michel Koenig

Magnetic Reconnections Driven by Electron Dynamics in the Presence of a Weak External Magnetic Field

PRESENTER: Yasuhiro Kuramitsu

ABSTRACT. We have been experimentally investigating magnetic reconnections driven by electron dynamics using high-power lasers. By controlling the external magnetic field strength, only electrons are magnetized in the experimental system. We have shown that magnetic reconnection can be driven by electron dynamics by imaging a cusp and plasmoid propagating at the Alfven velocity defined by electron mass [1]. Furthermore, by measuring the local electron and ion velocities, the pure electron outflows have been experimentally verified [2]. The electron dynamics can be essential in the Weibel instability in sub-relativistic collisionless shocks in the presence of a weak external magnetic field [3]. We report our recent efforts to extend reconnection experiments using relativistic intense lasers and also magnetic devices, together with magnetic field reconstruction with data science and informatics.

[1] Y. Kuramitsu et al., Nat. Commun., 9, 5109, 2018 [2] K. Sakai, Sci. Rep. 12, 10921, 2022 [3] Y. Kuramitsu, Y. Matsumoto, and T. Amano, Phys. Plasmas 30, 032109, 2023

09:05 V. Valenzuela-Villaseca, M. Bailly-Grandvaux, E. G. Blackman, J. P. Chittenden, F. Ebrahimi, W. Fox, J. Goodman, J. Griff-McMahon, J. W. D. Halliday, J. D. Hare, H. Ji, M. E. Koepke, S. V. Lebedev, S. Malko, S. Merlini, D. R. Russell, D. B. Schaeffer, L. G. Suttle, F. Suzuki-Vidal, G. F. Swadling, E. R. Tubman, C. A. Walsh and V. Zhang

Progress Towards Laboratory Modelling of Magnetized Accretion Disks and Plasma Jets Using Intense Laser and Pulsed-Power Generators

PRESENTER: V. Valenzuela-Villaseca

ABSTRACT. Rotating plasma disks orbiting a central object, like a black hole, are ubiquitous in the universe. However, questions regarding their dynamical evolution, such as the mechanisms of angular momentum transport and the role of magnetic fields in seeding instabilities, turbulence and launching jets, remain outstanding.

In this talk I will give an overview of a new generation of laboratory experiments fielded at high-energy-density facilities (the MAGPIE pulsed-power generator at Imperial College London and the OMEGA laser at the University of Rochester), designed to probe plasma physics relevant to accretion disks and jet-launching regions [1-4].

In these experiments, a differentially rotating plasma column is driven and sustained by the collision of multiple inflowing plasma jets. The free-boundary design allows the plasma to expand axially, forming supersonic rotating jets which remain collimated as they propagate through the vacuum chamber. The rotating plasma flows are high magnetic Reynolds number (ranging from 10^2 to 10^3) and has a quasi-Keplerian stratification. The experiments are supported by 3-D MHD simulations performed on the code Gorgon, which are used to model the formation, evolution and structure of differentially rotating plasmas. I will discuss the potential of these experiments to study the magneto-rotational instability, the Omega-effect, and the overall effect of magnetic fields in high-Rm rotating plasmas on laboratory scales.

[1] Ryutov, Astrophys. Space Sci (2011) [2] Bocchi et al., The Astrophys. J. (2013) [3] Valenzuela-Villaseca et al., Phys. Rev. Lett. (2023) [4] Valenzuela-Villaseca et al., IEEE Trans. Plasma Sci. (under review, 2024)

09:25 Taiki Jikei, Takanobu Amano, Yosuke Matsumoto and Yasuhiro Kuramitsu

Magnetic Amplification by the Weibel Instability in Weakly Magnetized Astrophysical Shocks and Laboratory Laser Experiments

PRESENTER: Taiki Jikei

ABSTRACT. It is considered that the Weibel instability amplifies the magnetic field in weakly magnetized collisionless shocks. Although the background magnetic field energy is much smaller than the ion kinetic energy, previous studies of astrophysical shocks imply that the background magnetic field could still have a large impact when the electrons are magnetized [1]. We show, by theory and particle-in-cell (PIC) simulations, that the magnetized electrons enhance the amplification of the Weibel-generated magnetic field and could trigger magnetic reconnection in the nonlinear evolution [2]. We apply this amplification mechanism to laboratory experiments utilizing high-intensity lasers [3]. We present the PIC simulation results of this setup and discuss possible applications, such as particle acceleration and fusion.

[1] Matsumoto Y., Amano T., Kato T. N., Hoshino M., 2015, Science, 347, 974 [2] Jikei T., Amano T., Matsumoto Y., 2024, ApJ, 961, 157 [3] Kuramitsu Y., Matsumoto Y., Amano, T., 2023, Physics of Plasmas, 30, 032109

09:40-10:10 Coffee Break

10:10-11:50 Session 25: Turbulence and Magnetized Shocks

CHAIR: Hantao Ji

LOCATION: Horizon Grand Ballroom

10:10 *Petros Tzeferacos*, *Archie Bott*, *Hannah Poole*, *Charlotte Palmer*, *Kasper Moczulski*, *Anthony Scopatz*, *Dustin Froula*, *Charles Heaton*, *Joseph Katz*, *Chikang Li*, *Nicolas Lopez*, *Hye-Sook Park*, *Patrick Reichherzer*, *Yangyuxin Zou*, *Adam Reyes*, *Steven Ross*, *Alexander Schekochihin*, *Donald Lamb* and *Gianluca Gregori*

Laboratory Evidence of Fluctuation Dynamo in Supersonic Turbulence

PRESENTER: *Petros Tzeferacos*

ABSTRACT. Highly compressible magnetized turbulence is prevalent in most astrophysical systems in the interstellar and intergalactic mediums, exhibiting signs of high compressibility (i.e., large sonic Mach numbers, M > 1). Supersonic turbulence is known to play a critical role in determining the star formation rate, the star formation efficiency, and the stellar mass distribution. Stochastic fluctuations in turbulent, supersonic, magnetized plasmas also have a marked effect on the magnitude of the magnetic fields that permeate them, namely, dynamo action. Tapping into the plasma's kinetic energy reservoir, the turbulent motions cause the magnetic fields to “stretch”, “twist”, and “fold”, a sequence of transformations that results in the amplification of the magnetic energy density. The latter quickly becomes a sizable fraction of the available kinetic energy density of the turbulent motions and the magnetic fields reach values consistent with observational data. While fluctuation dynamo is commonplace in astrophysical systems, it is hard to realize in terrestrial laboratories, especially in the supersonic limit where theory predicts that the mechanism is inefficient when compared to its subsonic counterpart. Here we demonstrate, using laser-driven experiments at the Omega Laser Facility, that supersonic turbulence is indeed capable of fluctuation dynamo action. The experiments exploit the mature TDYNO experimental platform we developed, which demonstrated turbulent dynamo in the laboratory for the first time [Tzeferacos et al. Nat. Comm. 9, 591, 2018], meticulously characterized it [Bott et al. Proc. Natl. Acad. Sci. U.S.A. 118, e2015729118, 2021] in the subsonic regime, and was extended to study supersonic magnetized turbulence [Bott et al. Phys. Rev. Lett. 127, 175002, 2021]. We detail the experiments we performed at Omega that led to this demonstration, as well as the FLASH simulation campaigns that we executed for the design and interpretation of the experiments.

The Flash Center for Computational Science acknowledges support by the U.S DOE NNSA under Awards DE-NA0002724, DE-NA0003605, DE-NA0003842, DE-NA0003934, DE-NA0004144, and DE-NA0004147, and Subcontracts 536203 and 630138 with LANL and B632670 with LLNL, and Awards. Support from the U.S. DOE ARPA-E under Award DE-AR0001272, U.S. DOE Office of Science, Fusion Energy Sciences under Award DE-SC0021990, and the National Science Foundation under Awards PHY-2033925 and PHY-2308844 is also acknowledged.

10:30 *Archie Bott*, *Hannah Poole*, *Charlotte Palmer*, *Charles Heaton*, *Patrick Reichherzer*, *Nicholas Lopez*, *Kasper Moczulski*, *Dustin Froula*, *Tim Johnson*, *Joseph Katz*, *Chikang Li*, *Hye-Sook Park*, *Richard Petrasso*, *Brian Reville*, *Adam Reyes*, *J. Steven Ross*, *Dongsu Ryu*, *Anthony Scopatz*, *Fredrick Séguin*, *Thomas White*, *Alexander Schekochihin*, *Donald Lamb*, *Petros Tzeferacos* and *Gianluca Gregori*

‘Dynamo Interrupted at Its Action’: Decaying Magnetic Fields in Turbulent Laser-Plasmas

PRESENTER: *Archie Bott*

ABSTRACT. Over the last ten years a series of laser-plasma experiments have proven the feasibility of investigating dynamo processes in the laboratory. Key findings of these experiments include the demonstration of bona fide dynamo action in subsonic turbulent plasmas with both low- and order-unity magnetic Prandtl numbers, amplification of magnetic fields in supersonic plasmas, and significantly modified transport of fast particles and heat by dynamo-generated fields. In this talk, I will present new results that address a previously unsolved puzzle from these experiments: how dynamo action ceases. Based on data from Thomson-scattering, X-ray imaging, and proton-radiography diagnostics, we argue that, once the plasma cools below a critical temperature, magnetic-field amplification is not sustained, and the fields that were initially generated by the dynamo subsequently decay. The implications of these results for the critical magnetic Reynolds number of dynamo action in both subsonic and supersonic turbulent laser-plasmas will be discussed.

We acknowledge support by UKRI (grant number MR/W006723/1); EPSRC (grant numbers EP/M022331/1 and EP/N014472/1), the European Research Council under the European Community's Seventh Framework Programme (FP7/2007-2013)/ERC grant agreements nos. 256973 and 247039; the U.S. DOE NNSA under Awards DE-NA0002724, DE-NA0003605, DE-NA0003842, DE-NA0003934, DE-NA0003856, and Subcontracts 536203 and 630138 with LANL and B632670 with LLNL; the NSF under Award PHY-2033925; and the U.S. DOE Office of Science Fusion Energy Sciences under Award DE-SC0021990.

10:50 *Derek Schaeffer*, *Victor Zhang*, *Margaux Francois*, *Philip Moloney*, *Peter Heuer*, *Katherine Chandler*, *Gennady Fiksel*, *Damiano Caprioli*, *Jeremy Chittenden*, *Emmanuel D'Humieres*, *Will Fox*, *Jack Hare*, *Frances Kraus*, *Carolyn Kuranz*, *Sergey Lebedev*, *Chuang Ren*, *Xavier Ribeyre*, *Danny Russell* and *Jonathan Davies*

Magnetized Collisionless Shocks on HED Facilities

PRESENTER: *Derek Schaeffer*

ABSTRACT. Magnetized collisionless shocks are ubiquitous in heliospheric and astrophysical environments, including planetary shocks, the heliopause, supernova remnants, and galaxy clusters. Magnetized shock dynamics are highly dependent on the angle θ between the upstream magnetic field and the shock propagation direction, with different physical

processes active in quasi-perpendicular (θ > 45 deg) and quasi-parallel (θ < 45 deg) geometries. Of particular interest are particle heating and non-stationary dynamics in quasi-perpendicular shocks and particle acceleration in quasi-parallel shocks. However, we currently lack an understanding of key aspects of how these processes operate, with multiple competing theories and incomplete hints from satellite observations of shocks in space. Recent advances have enabled collisionless shocks to be created experimentally using high-powered lasers [1,2]. We present two new experimental platforms that combine unprecedentedly large magnetized volumes with strongly driven plasma flows to study magnetized collisionless shocks: a platform on the Z Machine at SNL to explore particle heating and non-stationary dynamics in quasi-perpendicular shocks; and a platform on the National Ignition Facility at LLNL to create and measure ion acceleration in quasi-parallel shocks. Details on these platforms and the collisionless shock physics they can access will be discussed.

[1] Schaeffer, et al., Phys. Rev. Lett. 119, 025001 (2017) [2] Schaeffer, et al., Phys. Rev. Lett. 122, 245001 (2019)

11:10 Yuyao Wang, Luca Antonelli, Nathan Joiner, Francisco Suzuki-Vidal, Tim Ringrose and Nigel Woolsey

Laboratory Insights into Shock-Driven Turbulent Mixing

PRESENTER: Yuyao Wang

ABSTRACT. Our current understanding of shock-driven star formation and the mixing of stellar materials in the interstellar medium largely relies on limited observational data and sophisticated computational models. Despite their comprehensive scope, computational studies often face limitations in accurately capturing the full complexity of physical interactions. Turbulent mixing, resulting from the interaction between shocks and blast waves with denser clouds in the interstellar medium, simplifies under certain assumptions to become hydrodynamically self-similar. This self-similarity makes the problem suitable for detailed laboratory investigations over extended periods, providing a vital link between observational data and computational models.

The presented work focuses on the development of experimental platforms for conducting shock-cloud experiments. We have successfully utilized a modified 2-stage light-gas gun facility, enabling us to drive a planar Mach 3 shock through a 100 mbar nitrogen gas environment and across cylindrical foam targets with a 2 mm diameter and a density of 150 mg/cm3. The experimental outcomes revealed a cloud-crushing time of 1.8μs, aligning with the analytical solution derived by Klein et al. Compared to laser-driven shocks, our modified gas gun setup enables exploration in the low Mach number regime with larger targets for detailed observation. It sustains shock pressure for tens of microseconds, allowing for the observation of shock-target interactions over multiple cloud-crushing times.

We intend to expand our exploration of shock-driven mechanisms through the use of the inverse wire array Z-pinch pulsed power machine and high-power laser facilities. By employing a variety of target designs and cutting-edge diagnostics, we aim to study these interactions in different conditions, enhancing our understanding of the fundamental physics involved. This comprehensive insight is essential for unraveling the processes behind triggered star formation and for shedding light on similar turbulent mixing challenges seen in inertial confinement fusion experiments.

11:22 Yu Zhang, Peter Heuer, Chuang Ren, Jonathan Davies, Han Wen, Fernando García-Rubio and Derek Schaeffer

Particle Acceleration and Ion-Electron Energy Exchange in Quasi-Parallel Magnetized Collisionless Shocks

PRESENTER: Yu Zhang

ABSTRACT. Magnetized collisionless shocks are ubiquitous in the universe and have been long presumed to be the source of some of the highest energy cosmic rays. Quasi-parallel collisionless shocks (in which the shock normal is approximately parallel to the background magnetic field) are believed to be more efficient accelerators of particles than quasi-perpendicular shocks. 2-D kinetic simulations confirm that quasi-parallel shocks are capable of energizing more particles and creating energy spectra that extend further than from quasi-perpendicular shocks. In the shock downstream, ions and electrons reach an energy partition Ti/Te ~ 1.3, implying a significant electron heating due to ion-electron energy exchange. A multi-fluid model shows a resonance between electron whistler waves and ion magnetohydrodynamic waves that may be responsible for the energy transfer from drifting ions to thermal electrons.

This material is based upon work supported by the Department of Energy [National Nuclear Security Administration] University of Rochester “National Inertial Confinement Fusion Program” under Award No. DE-NA0004144, the Department of Energy under Award Nos. DE-SC0020431 and DE-SC0024566, and the resources of the National Energy Research Scientific Computing Center (NERSC), a U.S. Department of Energy Office of Science User Facility located at Lawrence Berkeley National Laboratory. The authors thank the UCLA-IST OSIRIS consortium for the use of OSIRIS.

11:34 Thomas Vincent, Archie Bott, Gianluca Gregori and Petros Tzeferacos

Design of Experiments on the Orion Laser to Measure Thermal Transport in High-β, Weakly Collisional Plasma

PRESENTER: Thomas Vincent

ABSTRACT. The study of thermal transport in plasmas is necessary for understanding many extreme environments observed in the Universe, including the intracluster medium (ICM) of galaxy clusters and in inertial-confinement fusion (ICF) experiments. Theoretical modelling of transport in these systems is challenging due to the multi-scale nature of the physics that determines this transport. A recent experiment performed using the National Ignition Facility (NIF) showed that thermal conductivity induced by electron transport in a high-β, weakly collisional, turbulent plasma was suppressed by two orders of magnitude compared to the classical Spitzer value. However, the complicated field geometries and flows present in the plasma made it difficult to pinpoint the cause of the suppression. One possible mechanism considered was suppression induced by microinstabilities, notably the whistler heat flux instability which has been predicted to suppress conduction for similar plasmas. Making new experimental measurements of thermal transport in such plasmas, with simpler magnetic-field geometries, could help constrain theoretical models more tightly.

This talk will outline an experimental design to measure parallel thermal transport in weakly collisional, high-β plasma on the Orion laser facility. A front-side blow-off plasma will be used to produce a weakly collisional, planar plasma. This plasma will be magnetised due to fields generated by the Biermann-Battery during its ablation, with the magnetic field lines being aligned with the temperature gradient in the plasma. We will make use of a spatially resolved gated X-ray detector (GXD), and a spatially and temporally resolved X-ray spectrometer for the temperature diagnostics. These in tandem will be able to give measurements of temperatures in the regions of interest. Magnetic-field measurements will be taken using proton imaging with two perpendicular target-normal sheath accelerated (TNSA) proton beams. Preliminary analysis has been done using simulation data gathered from the 3D MHD fluid code FLASH, as well as the collisional-radiative spectral analysis code SPECT3D. Insights from these simulations will help us deliver a successful campaign.

12:00-13:30 Lunch Break

13:30-15:15 Session 26: Opacity & Radiation

CHAIR: *Sam Vinko*

LOCATION: Horizon Grand Ballroom

13:30 *David Hoarty*, *John Morton* and *Jonathan Rougier*

Radiation Burn-Through Measurements to Infer Opacity at Conditions Close to the Solar Radiative Zone - Convective Zone Boundary.

PRESENTER: *David Hoarty*

ABSTRACT. Recent measurements at the Sandia National Laboratory of the x-ray transmission of iron plasma have inferred opacities much higher than predicted by theory which casts doubt on modelling of iron x-ray radiative opacity at conditions close to the solar convective zone-radiative zone boundary. An increased radiative opacity of the solar mixture, in particular iron, is a possible explanation for the disagreement in the position of the solar convection zone-radiative zone boundary as measured by helioseismology and predicted by modelling using the results of analysis of the elemental composition from the solar photosphere. Here we present data from radiation burn-through experiments which do not support a large increase in the opacity of iron at conditions close to the base of the solar convection zone and provide a constraint on the possible values of both the mean opacity and the opacity in the x-ray range of the Sandia experiments. The data agree with opacity values from current state-of-the-art opacity modelling using the CASSANDRA opacity code.

13:50 *Guillaume Loisel*

Time-Resolved Spectroscopy to Advance Stellar Opacity Efforts on Z

ABSTRACT. Opacity at solar interior conditions has been measured on Z and was found to be higher than predictions. This finding helps resolve the long-standing solar problem although no opacity-model revisions have been found to date. Sandia developed an ultrafast x-ray imager (UXI) that allows time-resolved absorption spectroscopy for the first time. Prior opacity data recorded on x-ray film had duration given by the 3-ns backlighter. One hypothesis for the opacity model-data discrepancy is that the temporal integration influenced the results. Time-resolved conditions have been constrained now and synthetic tests of temporal integration effect on past measurements did not resolve the source of the opacity discrepancy. But only actual time-resolved measurements would provide a model-free evaluation of this effect. Measurements of sample evolution of Fe at near solar interior conditions did not reveal an impact of temporal gradients on past film-based measurements. These time-resolved technique are now being applied to oxygen experiments, oxygen being the largest contributor to the Rosseland mean at the base of the solar convection zone. Besides, the focus of the effort is now on measuring absolute time-resolved opacity. We will also discuss the first results from experiments designed to take advantage of newly acquired time-resolved knowledge to better control and expand the opacity sample conditions. The strategy and prospects for obtaining multiple opacity measurements from a single Z experiment will be discussed.

Sandia National Laboratories is a multimission laboratory managed and operated by NTESS LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. DOE’s NNSA under contract DE-NA0003525.

14:10 *James Bailey*, *Guillaume Loisel*, *Taisuke Nagayama*, *Dan Mayes*, *Greg Dunham* and *Stephanie Hansen*

Progress in Understanding Stellar Interior Opacity with Laboratory Experiments at Z
PRESENTER: *James Bailey*

ABSTRACT. Discrepancies between the Standard Solar Model and helioseismology identified about 2 decades ago have yet to be resolved. Revising models for stellar matter opacity could be a key part of the explanation and laboratory experiments are underway to evaluate this possibility. Published data indicates that models underpredict iron opacity at stellar interior conditions but understanding why this is so remains elusive. Here we provide a summary of the effort centered on experiments at Z, including motivation, experiment methodology, expanded temperature/density regimes, measurements with multiple elements, and future directions. Sandia National Laboratories is a multimission laboratory managed and operated by NTESS LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. DOE’s NNSA under contract DE- NA0003525.

14:22 *Roberto Mancini*, *Jeffrey Rowland*, *Robert Heeter*, *Richard London*, *Kathy Opachich*, *Howard Scott* and *Sean Regan*
The Challenge of Producing Laboratory Photoionized Plasmas in Steady State
PRESENTER: *Roberto Mancini*

ABSTRACT. New experimental platforms have been established at the OMEGA EP and NIF laser facilities with the goal of producing and characterizing laboratory photoionized plasma in steady state. The latter has been a standing challenge of photoionized plasma experiments and is key to the goal of benchmarking astrophysical theory and modeling codes employed in the analysis and interpretation of x-ray astronomy observations. In the experiments, a tamped-foil sample is heated and ionized by the broadband x-ray flux from an array of laser-driven halfraums that can have a duration of up to 30ns with radiation temperatures of 90eV and 160eV at OMEGA EP and NIF, respectively. Silicon and iron photoionized plasmas have been produced that maximize the population of ions with open n=2 atomic shell. The x-ray source performance is monitored with soft x-ray spectrometers, and density is determined from an imaging measurement of the photoionized plasma expansion. Diagnostics also include transmission and self-emission x-ray spectroscopy. A separate source of backlit photons is fired at different times to check that the charged state distribution determined from the transmission spectrum analysis is in steady state. Furthermore, a novel analysis method is employed to extract the plasma temperature1. We discuss the relevant timescales, the experimental design and observations, the analysis of the data, and the comparison of experimental results with simulations performed with several astrophysical and non-astrophysical models and codes. 1R. C. Mancini et al Phys. Rev. E 101, 051201 (2020). This work is supported by DOE grant DE-NA0004038, and the NLUF and NIF Discovery Science Programs.

14:42 *Michael Springstead*, *H LeFevre*, *K Kelso*, *T Nagayama*, *G Loisel*, *J Bailey*, *S Klein*, *G Jaar*, *K Swanson*, *B Dunlap*, *P Cho*, *D Mayes*, *R Mancini*, *D Winget*, *J Davis*, *W Gray*, *R Drake* and *C Kuranz*
Laboratory Generated Photoionization Fronts Relevant to Astrophysics
PRESENTER: *Michael Springstead*

ABSTRACT. Photoionization (PI) fronts are a type of radiation-driven ionization wave that occur in many astrophysical systems. PI fronts dictate important physics in the observations of flash supernova spectroscopy and Stromgren sphere structures around stars. Traditionally, many radiation transport models propagate energy by diffusion and assume an optically thick medium. Photoionization fronts are typically modeled using non-diffusive radiation transport in optically thin materials. The difference in diffusive vs nondiffusive radiation transport has important consequences in the evolution of radiatively driven systems, such as star formation rates in circumstellar medium. The Z-machine at Sandia National Laboratories can create high-energy-density conditions in the laboratory relevant to PI fronts. The Z-Pinch Dynamic Hohlraum generates a bright high flux x-ray source that are incident on a nitrogen gas cell. The x-rays penetrate the gas and locally ionize the electrons over a short mean free path (~100 um) as a front that then propagates down the length of the gas cell (20 mm). Initial results show the photoionization front propagates at supersonic velocities and displayed curvature consistent with non-diffusive radiation transport. Future experiments will be carried out to compare results to astrophysical observations and theory

15:02 *Victor Tranchant*, *Fernando Garcia Rubio*, *Eddie Hansen* and *Petros Tzeferacos*
Studying Radiation Effects in Shocks and the Rayleigh-Taylor Instability with FLASH
PRESENTER: *Victor Tranchant*

ABSTRACT. Radiative shock waves can be found in a wide range of regimes, characterized mainly by three dimensionless parameters [1]. The Boltzmann number quantifies the effects of radiation flux, the Mihalas or radiative number quantifies the importance of radiative energy density, and the optical depth compares the photon mean free path and the characteristic length scale of the hydrodynamic system. However, a systematic classification has proven to be complex, as layers of optically thin and thick regions alternate to form precursors and relaxation regions, between which the hydrodynamic shock is embedded [2]. Here, we aim to study the effects of radiation on the formation of weak shocks when two radiative plasmas with different pressures are put in contact. The conditions upon which optically thin and thick solutions exist have been obtained and expressed as a function of the shock strength and Boltzmann number. The existence of an optically thin regime is related to the presence of an over-dense layer in the compressed material. Scaling laws for the characteristic time and length have been discovered for several regimes. The theoretical analysis is supported by FLASH simulations. Based on these findings, we investigate shock

wave formation in gas-puff implosions with a high atomic number liner, which is supposed to enhance radiative shock effects during compression [3]. In doing that, we tried to identify the parameters for which the over-compression regime is relevant on the time and length scales characteristic of Z-pinch design-space [4]. Then, we show that the new capabilities of the FLASH code have made it possible to simulate such radiative setups in 2D, capturing the Rayleigh-Taylor instability (RTI). We take advantage of the code's new capabilities to study the impact of radiation on RTI growth rate, attempting to infer the role of high energy fluxes on the possible mitigation of the instability. For this, we discuss a new theoretical study that could also be applied to the modification of RTI dynamics in astrophysical regimes such as supernovae remnants [5]. We acknowledge support by the Department of Energy (DOE) National Nuclear Security Administration (NNSA) under award numbers DE-NA0003856, DE-NA0003842, DE-NA0004144, and DE-NA0004147, under subcontracts no. 536203 and 630138 with Los Alamos National Laboratory, and under subcontract B632670 with Lawrence Livermore National Laboratory. We acknowledge support from the U.S. DOE Advanced Research Projects Agency-Energy (ARPA-E) under Award Number DE-AR0001272 and the U.S. DOE Office of Science under Award Number DE-SC0023246.

REFERENCES [1] Michaut, Claire, et al. "Classification of and recent research involving radiative shocks." Astrophysics and Space Science 322 (2009) [2] Drake, R. Paul. "Radiative shocks in astrophysics and the laboratory." High Energy Density Laboratory Astrophysics (2005) [3] E. Ruskov et al., "The staged Z-pinch as a potential fusion energy source", Phys. Plasmas (2020) [4] F. Garcia Rubio et al., "Shock Wave Formation in Radiative Plasmas", PRE, submitted (2024) [5] Kuranz, Carolyn C., et al. "How high energy fluxes may affect Rayleigh–Taylor instability growth in young supernova remnants." Nature communications 9.1 (2018).

15:15-15:45 Coffee Break

15:45-17:05 Session 27: Materials at High Pressures III

CHAIR: *Amy Jenei*

LOCATION: Horizon Grand Ballroom

15:45 *Michelle Marshall*, *Donghoon Kim*, *Danae Polsin*, *Ian Ocampo*, *Ryan Rygg*, *Tom Duffy*, *Terry-Ann Suer*, *Ray Smith*, *Jon Eggert*, *Andrew Krygier*, *Shuai Zhang* and *Rip Collins*

High-Pressure Phase Transformations in Ramp-Compressed SiO2

PRESENTER: *Michelle Marshall*

ABSTRACT. Dynamic compression experiments using high-power lasers enable studies of ultradense matter to terapascal pressures. Using these techniques, the high-pressure states of geological materials can be characterized in order to better understand the deep interiors of planets. Here, we report on the high-pressure solid phases of SiO_2, an archetype for the silicates that dominate terrestrial mantles. Fused silica was quasi-isentropically (ramp) compressed to ~500 GPa and its crystalline structure was probed in situ using simultaneous x-ray diffraction at the Omega Laser Facility. Preliminary results indicate the formation of the expected pyrite-type structure between ~250 and 500 GPa. We discuss future plans at the National Ignition Facility to extend this platform to higher pressure, where SiO_2 is predicted to transform into more highly coordinated phases.

This material is based upon work supported by the Department of Energy National Nuclear Security Administration under Grant No. DE-NA0004144. Funding for this research was provided by the Center for Matter at Atomic Pressures (CMAP), a National Science Foundation (NSF) Physics Frontiers Center, under Award PHY2020249.

16:05 *June Wicks*

Phase Diagram Models of Matter and the Kinetics of Phase Transitions at Extreme Conditions

ABSTRACT. An understanding of the pressure and temperature conditions of melt at extreme levels of compression is important for planetary interior and impact models, inertial confinement fusion designs, and the construction of predictive equation-of-state models. For many materials, shock compression studies provide the only method for experimentally constraining melt at extremes (100's GPa, ~1 eV), but the material states accessed by such rapid compression remain unclear. Here we present data which constrain the phase diagrams of magnesium oxide (MgO) and silicon carbide (SiC) and draw direct comparisons with melt theory by conducting laser-compression experiments along the shock Hugoniot with in situ X-ray diffraction, velocimetry, and pyrometry measurements to simultaneously determine crystal structure, microstructural texture, temperature, density, and pressure.

An atomistic description of melting under shock loading conditions has been explored by theory for decades, with different processes proposed. In the equilibrium view (no kinetic effects), as the shock Hugoniot intersects with the melt line, liquid formation initiates. Increasing increments of shock pressure results in P-T states along the melt line, with the liquid volume fraction increasing at the expense of the solid, until eventually full melt is achieved. In contrast, non-equilibrium molecular dynamic (NEMD) simulations, which calculate the states accessed in uniaxial shock compression of single crystals, have predicted either the formation of superheated solid states or supercooled liquid states. Our combined shock front temperature and bulk structural data on SiC suggests the formation of a transient supercooled liquid state at the shock front followed by recrystallization into the high pressure B1 phase, consistent with predictions of shear induced melting in other systems. This, however, is a distinctly orientation-dependent effect, as evidenced by data collected from uniaxial compression from different crystal orientations. In this talk, I draw

comparisons between experimental observations and state-of-the-art atomistic theory which reveal the complexities of melt at extremes of pressure and temperature.

16:25 Xuchen Gong, Danae Polsin, Reetam Paul, Brian Henderson, Michelle Marshall, Mary Kate Ginnane, Jon Eggert, Raymond Smith, Federica Coppari, J. Ryan Rygg and Gilbert W. Collins

High Pressure Phase Diagram of Silicon

PRESENTER: Xuchen Gong

ABSTRACT. The experiment described in this presentation explores the phase diagram of silicon near its isentrope from 40 to 400 GPa, by ramp compressing silicon by a laser drive. Thermodynamic states of silicon at these states are measured by velocimetry, and the crystal structure is determined by nanosecond in-situ x-ray diffraction. The experiment shows a significant increase of the stability range of the Si hcp phase compared to theoretical predictions. The hcp phase is observed at the pressure and temperature range where dhcp phase was predicted, and no evidence of the dhcp phase is observed. Furthermore, the hcp-fcc phase transition pressure is at least 93 GPa, much higher than the 55 GPa predicted by computation. This observation is consistent with previous shock compression experiments. The fcc phase is confirmed to remain stable to at least 400 GPa.

Currently, no temperature data exist from nanosecond pyrometric measurements on ramp compression experiments. Such measurements are difficult due to the low number of photons emitted from low temperature (lower than 4000 K) targets. In this work, we present the foundational framework for analyzing low signal-to-noise ratio data. This method yields identical results as traditional techniques at high temperatures but is more robust at low temperatures. This sets the stage for analyzing future low temperature pyrometry data.

16:45 Hannah Poole, Mary Kate Ginnane, Marius Millot, Gilbert Collins, Suxing Hu, Danae Polsin, Tom White, David Chapman, Ryan Rygg, Sean Regan and Gianluca Gregori

Multi-Messenger Measurements of the Static Structure of Shock-Compressed Liquid Silicon at 100 GPa

PRESENTER: Hannah Poole

ABSTRACT. We have used the high-power laser facility OMEGA-EP at the Laboratory for Laser Energetics to measure the liquid structure of the shock-compressed state of warm dense silicon. Using velocity interferometry and X-ray scattering techniques, concurrent characterization of the compressed sample provided direct measurement of the static structure of silicon in its liquid phase. By combining the predictions of an X-ray scattering model with the analytical technique of Markov-Chain Monte Carlo, convergence of the density and inferred pressure state was found for three unique ion-ion correlation models; effective Coulomb, Debye-Huckel and non-linear Hulthen. Mutual posterior distributions of the silicon state were found by comparing these convergences with the pressure-density state determined by impedance matching techniques. The subsequent parameter distributions on the silicon phase diagrams highlight a consistency between the non-linear Hulthen predictions and the principal Hugoniot. This is a powerful experimental development allowing for exploration of the equation-of-state of high-compression materials which are readily achieved at high-power laser facilities and reducing model selection biases.

This material is based upon work supported by the Department of Energy National Nuclear Security Administration under Award Number DE-NA0003856, the University of Rochester, and the New York State Energy Research and Development Authority. Part of this work was prepared by LLNL under Contract No. DE-AC52–07NA27344.

HEDLA-2024: THE 14TH INTERNATIONAL CONFERENCE ON HIGH ENERGY DENSITY LABORATORY ASTROPHYSICS

PROGRAM AUTHORS KEYWORDS

PROGRAM FOR FRIDAY, MAY 24TH

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06:45-08:00 Session 28: Breakfast

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08:05-09:35 Session 30: Hydrodynamic Instabilities

CHAIR: *Petros Tzeferacos*
LOCATION: Horizon Grand Ballroom

08:05 *Hong Sio*, *Victorien Bouffetier*, *Gabriel Pérez-Callejo*, *Luke Ceurvorst*, *Jonathan Peebles*, *Petros Tzeferacos*, *Vladimir Smalyuk*, *Omar Hurricane* and *Alexis Casner*

Laboratory Investigations of Magnetized Kelvin-Helmholtz Instability on NIF and OMEGA

PRESENTER: *Hong Sio*

ABSTRACT. Magnetized Kelvin-Helmholtz instability (KHI) develops between two magnetized fluids flowing pass one another, producing a shear layer. The stabilizing effect of a tangential magnetic field along the shear velocity is well-known since Chandrasekhar in 1961, and supersonic stabilization for non-magnetized KHI was conjectured by Landau in 1944. Compressible magnetized KHI encompasses both space and fusion applications, from magnetosphere and solar wind physics [1], to edge tokamak plasma and hohlraum-gas interface [2] in indirect-drive inertial confinement fusion implosions. Yet, there has been sparse experimental data in this compressible, magnetized regime.

By combining the stabilization effects of compressibility and a strong external magnetic field in the laboratory, we aim to demonstrate mitigation of instability growth in a magnetized KHI scenario. At the OMEGA laser facility, we built upon the previous successful non-magnetized Kelvin-Helmholtz platform [3,4], adding a pre-imposed magnetic field, driving a shock across a plastic-foam interface, and imaging the instability growth using a point-projection X-ray backlighter. At the National Ignition Facility (NIF), the much larger amount of available laser energy enables a new ongoing experiment platform with robust post-shock flow at late time, and also hotter plasma conditions to mitigate the diffusion of magnetic fields across the mixing region. We will discuss the development of and data from these two experimental platforms on OMEGA and the NIF, and comparison to magnetohydrodynamic simulations.

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

[1] V. G. Merkin, et al., J. Geophys. Res. Space Physics, 118, 5478–5496. (2013) [2] M. Vandenboomgaerde, et al, Physics of Plasmas 23, 052704 (2016). [3] O. A. Hurricane, et al., Phys. Rev. Lett. 109, 155004 (2012) [4] V. A. Smalyuk, et al., High Energy Density Phys. 9, 47-51 (2013)

08:25 *Forrest W. Doss*, *D. A. Yager-Elorriaga*, *P. F. Knapp*, *G. A. Shipley*, *E. C. Merritt*, *C. Jennings*, *M. R. Martin*, *D. E. Ruiz*, *A. J. Porwitzky*, *S. W. Cordaro*, *L. Shulenburger* and *T. R. Mattsson*

Investigating Richtmyer-Meshkov Instabilities at High Energy Densities on the Z Machine

PRESENTER: *Forrest W. Doss*

ABSTRACT. Hydrodynamic instabilities are ubiquitous in inertial confinement fusion implosion scenarios, leading to loss of energy for compression and to mix of dissimilar materials. In order to study them and assess their impact, dedicated instability experiments have been performed using the Z Machine at Sandia National Laboratories. Complementary to laser-driven instability experiments, pinch-driven experiments naturally drive interfaces in their light-to-heavy configuration and include the effects of cylindrical convergence. We present experimental results and simulations of a suite of platforms investigating the Richtmyer-Meshkov (RM) process and interfacial feedthrough. Liners filled with liquid deuterium are magnetically imploded, driving a converging shock to the central axis and creating a magnetically isolated region suitable for studying hydrodynamic processes. The first platform investigates the interaction of this shock with a solid beryllium rod machined with sinusoidal perturbations that then grow under RM. The second replaces the on-axis rod with another cylindrical liner, enabling investigation of the feedthrough of these instabilities to the inner surface.

*This work conducted for the U.S. DOE by LANL under contract 89233218CNA000001 and by SNL under contract DE-NA0003525

08:37 Michael Wadas, Heath LeFevre, Loc Khieu, Griffin Cearley, Carolyn Kuranz and Eric Johnsen
Scaling of Vortex Rings Ejected from Shocked Interfaces
PRESENTER: Michael Wadas

ABSTRACT. As the shock passes through the layers of a collapsing star during type II supernovae, baroclinic vorticity generated at interfaces between layers stimulates mixing via the Richtmyer-Meshkov instability (RMI). Previous research ties the RMI to the ejection of high-velocity projectiles thought to be responsible for the early detection of stellar core elements following Supernova 1987A. Predicting and characterizing these projectiles, however, remains challenging. Recent improvements in experimental diagnostics and numerical simulations reveal that such projectiles share key characteristics with classical fluid vortex rings, thus enabling a path to understand their dynamics. Our objective is to isolate the ejection of vortex rings from shocked interfaces and determine their scaling through numerical simulations and experiments at the Omega EP Laser facility. We generate an isolated vortex ring by passing a shock through an interface between a heavy and light fluid along which there is a protrusion of heavy fluid into the light. After shock passage, the protrusion inverts, generating a jet led by the vortex ring. Our theoretical and computational results show that the strength of the vortex rings expectedly scales with the intensity of density and pressure gradients but saturates beyond a critical protrusion size, enabling an a priori prediction of the energy transported by vortex rings in RMI flows.

08:57 Riccardo Bonazza
Scaling of Shock-Driven Flows over Two Orders of Magnitude in Length Scales Between Shock Tube and NIF Environments

ABSTRACT. Shock propagation across the interface between regions of different acoustic impedance leads to the unbounded amplification of any perturbations initially present on the interface (the Richtmyer-Meshkov instability, RMI) which eventually leads to the development of a turbulent mixing region. Shock propagation through a molecular cloud of a supernova remnant (SNR) has been proposed as a mechanism for triggering star formation, with possible relevance to star-burst galaxies.

In the past, experimental campaigns have been performed on the NIF and OMEGA facilities to study the scalability of the Rayleigh-Taylor instability (RTI) across length scale and time scale factors of 3. Experimental studies of the RMI have taken place in shock tube facilities (at energy densities far below those of an astrophysical event) and on laser-driven facilities (where the energy density is much closer to prototypical) but appropriate scaling between the two regimes is still an open question and represents the motivation for the present work.

Experiments will be performed on NIF to study the RMI of a shock-accelerated material interface in a light-to-heavy geometry, following its evolution to long post-shock times, well into the highly non-linear regime. The results will be compared in a scaled sense to shock tube experiments at spatial and time scales that are factors of 10-100 longer. The main objectives are (1) to assess scalability of the results across large ranges of length scales and shock strengths, and (2) quantify the influence of strong compression effects (adjustable on NIF but not present in the shock tube) on the RMI. Both these issues are of significant relevance to astrophysical settings. The results will also provide a new database that can be used in benchmarking and calibrating computer codes (like ARES) developed specifically to describe this type of physics. The NIF is the only facility capable of delivering the required energy densities for these high Mach number RMI experiments, the time scales to reach the deep nonlinear RMI regimes and the ability to shape the laser pulse to ensure minimal interface deceleration after the initial shock-induced step in velocity.

A planar shock wave will be generated in a halfraum using a CH(I) ablator. The shock will propagate into a CRF foam layer followed by a CH(I) layer, with a perturbed interface between the two. Side-on imaging will be performed to measure the perturbation amplitude time history. One of the main novelties of this setup is the direction of propagation of the shock, from the light to the heavy material. Because of this, the post-shock deceleration of the interface will not lead to the RTI (with exponential amplitude growth rates that would overtake the RMI growth) but to steady, bounded oscillations whose effect on the RMI is predicted to be small.

The central question is how the RMI growth rates scale between the shock tube and NIF. For moderate shock strengths, it is expected that the hydrodynamics of the shock-interface interactions are decoupled from compression effects at least over the range of Mach numbers covered in NIF experiments at moderate laser intensities. Conversely, at high laser intensities, our experiment would offer a first measure of the degree of coupling between the RMI hydrodynamics and compression effects at an embedded interface (far from the ablation front).

09:17 E. C. Merritt, F. W. Doss, C. A. Di Stefano, R. Sacks, A. M. Rasmus, J. M. Levesque, K. A. Flippo, H. F. Robey, D. W. Schmidt, N. S. Christiansen, M. Millot, L. Kot, T. S. Perry and D. D. Meyerhofer
First Observations of Distinct RM Growth Scenarios for Successively Shocked Interfaces
PRESENTER: E. C. Merritt

ABSTRACT. Inertial Confinement Fusion (ICF) and High-Energy Density Physics (HEDP) experiments experience complicated forcing for instability growth and mix, due to the ubiquitous presence of multiple shocks interacting with perturbations on multiple material interfaces, including successive shocks from the same direction. There is a severe lack of analytic work and modeling validation for same-sided successive shocks since they are extremely difficult to achieve with conventional (non-HED) drivers. Successive shocks access a large instability parameter space; idealized fluid theory [Mikaelian, Physical Review A 31(1), 410 (1985)] predicts 15 different interface evolution scenarios for just a single mode, corresponding to three different vorticity competition cases. Growth becomes more complex for multi-mode, compressible HED systems. The Mshock campaign is the first experiment in any fluid regime to probe a wide portion of successive shock parameter space and deliver data capable of rigorously challenging our models and their ability to accurately capture Richtmyer-Meshkov growth under successive shocks.

Single-mode experiments have successfully demonstrated the ability to access and control the various growth states of the shocked interface, including re-inversion, freeze-out, and continued growth [Merritt et al., Physics of Plasmas 30, 072108 (2023)]. Data agrees among experiment, theory, and simulation in the linear growth phase, giving us confidence in our ICF/HED design codes (Fig. 1). Multi-mode experiments demonstrate distinct growth scenarios for the different modes and form a first basis of tests for initialization parameters of non-linear instability and turbulence models [Braun and Gore, Physica D 404 (2020] in this regime. *This work conducted under the auspices of the U.S. DOE by LANL under contract 89233218CNA000001 and by LLNL under Contract Nos. DE-AC52-07NA27344.

09:35-10:05 Coffee Break

10:05-11:30 Session 31: Materials at High Pressures IV

CHAIR: Tilo Doeppner

LOCATION: Horizon Grand Ballroom

10:05 Gaia Righi, Yong-Jae Kim, Thomas Lockard, Matthew Hill, James McNaney, Robert Rudd and Hye-Sook Park

Design of Laser-Driven High-Pressure Iron Rayleigh–Taylor Strength Experiments

PRESENTER: Gaia Righi

ABSTRACT. The high-energy density properties of iron are largely unconstrained and require complicated laser-driven experiments to probe. The design of such experiments involves the use of multimaterial fluid codes to model and predict laser absorption and material dynamics. The Rayleigh-Taylor (RT) instability can be used to infer iron strength or viscosity at multi-megabar pressures and thousands of Kelvin temperatures. The target and laser pulse shape are carefully designed using 1- and 2D hydrodynamic simulations to compress the iron to planetary relevant conditions of 150-300 GPa and 4000-6000 K. Strength/viscosity is then inferred from cross-comparison of experimental and simulated growth of RT unstable ripples [1]. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. [1] G. Righi, et al., JAP 131 (2022) 145902.

10:25 Yong-Jae Kim, Gaia Righi, Orlando Deluigi, Robert Rudd, Bruce Remington, Carlos Ruestes, Camelia Stan, Christopher Wehrenberg, Marc Meyers, Eduardo Bringa, Arianna Gleason and Hye-Sook Park

Laser-Driven Rayleigh-Taylor Strength Measurements of Iron

PRESENTER: Yong-Jae Kim

ABSTRACT. Iron (Fe) is one of the most abundant elements in the universe and is found in a wide range of astronomical objects. Understanding its strength at extreme pressure-temperature conditions is crucial for better understanding the interior structures and processes of celestial bodies, such as planetary core formation, seismic wave propagation, magnetic field generation, and impact event. Here, we present laser-driven Rayleigh-Taylor instability experiments for measuring the strength of iron. A physics package, consisting of a ripple interface between lighter epoxy and heavier iron, is directly accelerated by a high-power laser. The Rayleigh-Taylor growth of the ripple amplitude is measured using face-on x-ray radiography. Hydrodynamic simulations are performed to extract the pressure, temperature, flow stress, and strain profiles during acceleration. Our results provide dynamic strength data for two single-crystalline irons ([100] and [111] orientations) and a FeNi alloy (35 at% Ni in Fe) up to 350 GPa and 6 kK at strain rates of 10^-7-10^-8 /s. In summary, this study contributes to our understanding of iron's behavior under extreme conditions, especially the effects of crystalline orientation and alloying, with implications for various fields of geophysics, planetary science, and astrophysics.

* This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

10:45 Amy Lazicki, Martin Gorman, Sabri Elatresh, Marc Cormier, Stanimir Bonev, David McGonegle, Richard Briggs, James Ryan Rygg, Amy Coleman, Stephen Rothman, Lisa Peacock, Joel Bernier, Federica Coppari, David Braun, Dayne Fratanduono, Roald Hoffman, Gilbert Collins, Justin Wark, Raymond Smith, Jon Eggert and Malcolm McMahon

Experimental Observation of Open Structures in Elemental Magnesium at Terapascal Pressures

PRESENTER: Amy Lazicki

ABSTRACT. Investigating how solid matter behaves at enormous pressures, such as those found in the deep interiors of giant planets, is a great experimental challenge. Over the past decade, computational predictions have revealed that compression to terapascal pressures may bring about counter-intuitive changes in the structure and bonding of solids as quantum mechanical forces grow in influence. Although this behaviour has been observed at modest pressures in the highly compressible light alkali metals it has not been established whether it is commonplace among high-pressure solids more broadly. We used shaped laser pulses at the National Ignition Facility to compress elemental Mg up to 1.3 TPa, which is approximately four times the pressure at the Earth's core. By directly probing the crystal structure using nanosecond-duration X-ray diffraction, we found that Mg changes its crystal structure several times with non-close-packed phases emerging at the highest pressures. Our results demonstrate that phase transformations of extremely condensed matter, previously only accessible through theoretical calculations, can now be experimentally explored.

11:05 *Andrew Krygier*, *Hong Sio*, *Stan Stoupin*, *Rob Rudd*, *Stanimir Bonev*, *Dave Braun*, *Federica Coppari*, *Amy Coleman*, *Jon Eggert*, *Amy Jenei*, *Bernie Kozioziemski*, *Ryan Rygg*, *James McNaney* and *Yuan Ping*

Temperature Determination in Multi-Mbar Pressure Solids with Extended X-Ray Absorption Fine Structure at the National Ignition Facility

PRESENTER: *Andrew Krygier*

ABSTRACT. Dynamic compression is now a widespread technique for investigating material properties at extraordinary pressure, density, and temperature. However, there is a nearly complete lack of temperature measurements across the full scope of this field, leaving thermal effects as a large source of uncertainty. Extended X-ray Absorption Fine Structure (EXAFS) is is sensitive to density, temperature, and crystal structure in the range 100s-10000 K, where most materials form a solid at high pressure. Here we present results of experiments at the National Ignition Facility (NIF) that measured EXAFS from both copper [1] and tantalum compressed to multi-Mbar pressures along both shock and ramp compression paths. These measurements are made possible by the high flux x-ray source [2] and high fidelity laser pulse shaping available at the NIF, as well as the high-resolution x-ray spectrometer design [3]. L-edge EXAFS, which is required for high atomic number materials, is particularly challenging due to intrinsically small amplitude EXAFS oscillations compared to K-edge. We discuss these results in the context of predicted thermal states, thermal diffusion on nanosecond timescale, detailed strength models, and design of future experiments.

1. Sio et al. "Extended X-ray absorption fine structure of dynamically-compressed copper up to 1 terapascal" Nature Communications 14, 7046 (2023) 2. Krygier et al. "Optimized continuum x-ray emission from laser-generated plasma" Appl. Phys. Lett. 117, 251106 (2020) 3. Stoupin et al. "The multi-optics high-resolution absorption x-ray spectrometer (HiRAXS) for studies fo materials under extreme conditions" Rev. Sci. Instrum. 92, 053102 (2021)

This work was performed under the auspices of U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract No. DE-AC52-07NA27344.

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Instructions for Speakers and Session Chairs

- We have a few comments related to organization of the meeting and its scientific sessions.

  Presentations must be uploaded to the presentation computer attached to the speaker's stand.

  Use of personal computers for presentations is disallowed. There will be no exceptions.

- Michael McDonald (and occasionally perhaps Li or John Thompson) of the LOC will be available at the speaker's stand to help uploading individual presentations to the presentation computer. They will also provide general technical support for you and your session chair. The same A/V setup will be used on all conference days.

- The preferred presentation formats are **PowerPoint, PDF, or Keynote**. You can also submit your presentation to the LOC via email at hedla2024@gmail.com, or use one of file sharing services (i.e. Dropbox, Google Drive). We strongly discourage last minute downloading of presentation using the available hotel wifi network.

- Uploaded presentations will be reviewed to make sure they show correctly. This is a critical step for the session progresses smoothly, and possibly the most time consuming.

  Please meet with your session chair at the speaker's stand 30 minutes before your session starts to allow for enough time to complete the above process. For example, speakers in the first morning session should come to the speaker's stand around 7:35am.

- The presentation computer will be equipped with a mouse and you will be able to use a virtual pointer using computer's touchpad.

- A lapel microphone will be provided to overcome any possible issues with the room acoustics.

- Time allocated for talks varies between 12 and 20 minutes. Please allow some time for questions and discussions after the talk, for example,

  "20 minute talk" is **16 minutes plus 4 minutes** questions/discussion
  "12 minute talk" is **10 minutes plus 2 minutes** questions/discussion