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Conference Grant Report

The project title:	2023 High Energy Density Science Summer School
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FOA Number:	DE-FOA-0002844
DOE/SC Program Office:	Office of Fusion Energy Science
DOE/SC Program Office Technical Contact:	Dr. Kramer Akli
DOE Award Number:	n/a
PAMS Preproposal Tracking #:	n/a

Research area: Fusion Energy Sciences - High Energy Density Laboratory Plasmas

I. Introduction

The University of California San Diego (UCSD) hosted the High Energy-Density Science (HEDS) Summer School from July 17 – 28, 2023 on the UCSD campus. The goal of the Summer School was to introduce new talent to the breadth of the U.S. HEDS community through lectures, engaging workshops, and discussion sessions with leaders in academia and the national laboratories. The objectives were to inspire young scientists to pursue graduate and professional careers in the fields of HEDS, teach them fundamental HEDS and critical skills, and grant them the opportunity to network with leading academic and national laboratory researchers. Our focus was to attract promising early-career students from across the country.

This was the seventh time that the Summer School was held at UC San Diego. This **two-week** summer school promoted scholastic development through technical lectures given by **field experts** as well as professional development sessions aimed at early-career researchers in **High Energy Density Science** fields of study. The summer school included over **120 attendees**, including students and postdoctoral scholars, from **36 institutions** and **17 countries**. Fig. 1 shows a group photo of summer school participants. Additional support and course instruction came from 42 scientists and professors.

Figure 1*: Group photo* that features the *2023 participants of the High Energy-Density Science Summer School*

II. Meeting Report

Program Format

The HEDS field encompasses HED astrophysics, HED laboratory plasmas, and ultra-fast/ultra-intense laser-matter interactions. HEDS also spans fundamental topics ranging from strong-field physics to creating new states of matter including radiation-dominated, strongly coupled, quantum and relativistic plasmas. Important applications of HEDS research include basic science, inertial fusion, material science, and advanced HED technologies research and development.

This year's curriculum focused on the following topics (see attached program schedule for details):

- Fundamentals of Plasma Physics
- Introduction to High Energy Density Science
- Introduction to radiation and atomic physics in plasmas
- Laser-driven hydrodynamics and shocks
- Diagnostic methods and existing platforms
- Physics of Laser Plasma Interactions
- Fundamentals of Planetary Science
- Introduction to pulsed power technology
- Methods of target fabrications

Lectures on the above topics were given by experts affiliated with the Sandia National Laboratories (SNL), Lawrence Livermore National Laboratory (LLNL), and the Laboratory for Laser Energetics (LLE), flagship universities namely, University of California San Diego (UCSD), University of California Davis (UCD), University of Rochester (UR), and Prism Computational Sciences, Inc. Besides these, the Summer School presented special sessions including:

- Project-based learning:
    - Kinetic plasma physics coding workshop,
    - Fluid modeling of plasmas workshop, and
    - Machine learning workshop
- Special session on Inertial Fusion Energy
- Opportunities for students to present their research as a formal talk or poster
- Panel discussion on career options in HEDS
- Tours of UC San Diego and General Atomics research facilities
- Lecture on EDI
- Lecture on presentation skills
- Tours at HEDS experimental and target fabrication facilities at UCSD and GA, respectively

The three workshops were led by Alex Arefiev (UC San Diego), Petros Tzeferacos (University of Rochester) and Patrick Knapp (LANL) with support from Frank Tsung (University of California, Los Angeles), Igor Golovkin (Prism), and Raspberry Simpson (LLNL). Students who chose the kinetic modeling workshop were taught about differential equation solvers, particle-in-cell code construction, and were assigned a plasma physics phenomenon to study with one of various Vlasov or PIC codes. Students in the fluid modeling workshop were introduced to a one-dimensional (1-

D) radiation hydrodynamic code and then guided in the use of the 2-D code FLASH by its steward. They were assigned plasma physics phenomena to explore using the code. Students in the machine learning workshop were coached about data mining from high repetition rate experiments from short pulse laser matter interactions. Fig. 2 shows photographs of students engaged in discussion during the three workshops.

Figure 2: Summer School students gain hands-on experience during workshops on kinetic plastic physics coding, fluid modeling of plasmas, and machine learning.

Supported students were required to present either an oral talk or poster on the second Monday. This gave them an opportunity to be actively engaged in the discussion of collaborative experiments and present their work to colleagues and potential employers. Fig. 3 shows students presenting their work in poster sessions.

Figure 3: Summer students presenting during poster sessions and the recipients of the best oral and poster presentation awards.

Lectures from the Summer School have been made available in PDF format to participants online via a password-protected section of the school website.

Program Participation

57 applications received funding support for student travel and accommodations; preference given to early-track students at U.S. institutions and decisions were based on resumes and two letters of recommendation. A list of supported students from DOE grant is included in the Appendix.

III. Equity, Diversity, and Inclusion (EDI)

Historically, the fields of HEDS and plasma physics broadly have not been inclusive of women, minorities, and people from disadvantaged backgrounds. UC San Diego has put significant effort and resources to address issues of EDI. For example, the Center for Faculty Diversity and Inclusion works to cultivate an academic culture of inclusive excellence on campus. The main goal of the Center is to create a culture where everyone can succeed and advance. The Center of Excellence on Matter Under Extreme Conditions (CMEC) which hosted the summer school followed a similar principle and recognized that creating an environment that actively supports EDI is a critical part of building a more inclusive workforce, as well as driving scientific progress and innovation. CMEC aspires to create a diverse, equitable, and inclusive workforce where all are welcome and valued, are comfortable bringing their authentic selves, and have the opportunities, resources, and support to thrive. One lecture during the HEDS Summer School was devoted to emphasizing the principles of EDI to the participants and the lecturer engaged students by surveying questions on various aspects of EDI.

UC San Diego follows a strict code of conduct: https://blink.ucsd.edu/HR/policies/conduct/index.html. The Summer School followed the same code of conduct and as it strictly implements policy outlined in the above link during the summer school.

IV. Appendix

Schedule

2023 HEDS Summer School Schedule				
	Sunday, July 16	**Monday July 17**	**Tuesday, July 18**	**Wednesday, July 19**
7:15		Breakfast in Pines	Breakfast in Pines	Breakfast in Pines
7:30				
7:45				
8:00		WALKING	WALKING	WALKING
8:15		Welcome and Opening Remarks	Thomson scattering [Froula, UR] (15min break)	Introduction to short pulse laser interactions [Shepherd, LLNL] (15min break)
8:30		Vice Chancellor Corinne Peek-Asa		
8:45		Fundamental plasma physics [Holland, UCSD]		
9:00				
9:15				
9:30				
9:45		Introduction to HED physics [Collins, LLE] (15min break)	HED diagnostics I [Kilkenny, LLNL] (15min break)	Laser-plasma instabilities I [Mori, UCLA] (15min break)
10:00				
10:15				
10:30				
10:45				
11:00				
11:15		BREAK	BREAK	BREAK
11:30		Atomic and radiation physics [Nagayama, SNL]	HED diagnostics II [Chen, LLNL] (15min break)	Laser-plasma instabilities II [Mori, UCLA] (15min break)
11:45				
12:00				
12:15				
12:30				
12:45				
13:00		WALKING	WALKING	WALKING
13:15		Lunch in Pines	Lunch in Pines	Lunch in Pines
13:30				
13:45				
14:00	2:00 p.m. Campus Housing Opens	FREE	FREE	FREE
14:15				
14:30		Poster Session I	Poster Session II	Workshops
14:45				

15:00				Auditorium: Hydrodynamic modeling [Tzeferacos, Golovkin] Malamud: machine learning [Knapp, Simpson] Deutz: kinetic modeling [Tsung, Arefiev]
15:15				
15:30				
15:45				
16:00		Short Talks Session I	Short Talks Session II	
16:15				
16:30				
16:45				
17:00				
17:15				
17:30				FREE
17:45				
18:00				
18:15		FREE	FREE	
18:30	Dinner in Pines	Dinner in Pines	Dinner in Pines	Dinner in Pines
18:45				
19:00				
19:15	Welcome Reception Dessert & Drinks / Registration Institute of Americas Plaza			
19:30				
19:45				
20:00				

2023 HEDS Summer School Schedule

	Thursday, July 20	**Friday, July 21**	**Saturday, July 22**	**Sunday, July 23**
7:15	Breakfast in Pines	Breakfast in Pines	Breakfast in Pines	Breakfast in Pines
7:30				
7:45				
8:00	WALKING	WALKING	FREE	FREE
8:15	Fundamentals of planetary science [Jeanloz, Berkeley] (15min break)	Basics of particle acceleration with lasers [Geddes, LBNL] (15min break)		
8:30				
8:45				
9:00			Work on your individual projects!	FREE
9:15				
9:30				
9:45	Theoretical aspects of planetary	Applications of laser-generated particle		
10:00				

10:15	science [Militzer, UCB] (15min break)	sources [Albert, LLNL] (15min break)		
10:30				
10:45				
11:00				
11:15	BREAK	BREAK		
11:30	Giving technical presentations [Paul Krueger, UCSD] (15min break)	LaserNetUS/NLUF proposals [Curry, SLAC] (15min break)		
11:45				
12:00				
12:15				
12:30				
12:45				
13:00	WALKING	WALKING		
13:15	Lunch in Pines	Lunch in Pines	Lunch in Pines	Lunch in Pines
13:30				
13:45				
14:00	FREE	FREE	Work on your individual projects!	FREE
14:15				
14:30	Workshops Auditorium: Hydrodynamic modeling [Tzeferacos, Golovkin] Malamud: machine learning [Knapp, Simpson] Deutz: kinetic modeling [Tsung, Arefiev]	Workshops Auditorium: Hydrodynamic modeling [Tzeferacos, Golovkin] Malamud: machine learning [Knapp, Simpson] Deutz: kinetic modeling [Tsung, Arefiev]		
14:45				
15:00				
15:15				
15:30				
15:45				
16:00				
16:15				
16:30				
16:45				
17:00				
17:15				
17:30	FREE	FREE		
17:45				
18:00				
18:15				
18:30	Dinner in Pines	Dinner in Pines	Dinner in Pines	Dinner in Pines
18:45				
19:00				
20:00				

2023 HEDS Summer School Schedule					
	Monday, July 24	**Tuesday, July 25**	**Wednesday, July 26**	**Thursday, July 27**	**Friday, July 28**
7:15	Breakfast in Pines	Breakfast in Pines	Breakfast in Pines	Breakfast in Pines	Breakfast in Pines
7:30					
7:45					
8:00	WALKING	WALKING	WALKING	WALKING	WALKING
8:15	The technology of pulsed power [LeChien, SNL] (15min break)	Introduction to ICF I: a hydro perspective [Betti, UR] (15min break)	History of ICF [Campbell] (15min break)	Workshop group final presentations (Deutz Room) and poster/oral awards	Rep-rated HED [Mariscal, LLNL] (15min break)
8:30					
8:45					
9:00					
9:15					
9:30					
9:45	Fundamentals of the Z-pinch and its applications in magneto inertial fusion [Gomez, SNL] (15min break)	Introduction to ICF II: a hydro perspective [Betti, UR] (15min break)	ICF and Ignition on NIF [Zylstra, LLNL] (15min break)		Equity, Diversity, and Inclusion [Welch, UCSD] (15min break)
10:00					
10:15					
10:30					
10:45					
11:00					
11:15	BREAK	BREAK	BREAK	BREAK	BREAK
11:30	Fundamentals of EUV lithography [Hahn, ASML] (15min break)	Laboratory Astrophysics [Gregori, Oxford] (15min break)	IFE overview [Williams, LLNL] (15min break)	Target fabrication at LLNL for HED [Staderman, LLNL]	New material structure at high pressure [Hemley, UIC] (15min break)
11:45					
12:00					
12:15				Target fabrication at GA for HED [Fitzsimmons, GA]	
12:30					
12:45					
13:00	WALKING	WALKING	WALKING	WALKING	WALKING
13:15	Lunch in Pines	Lunch in Pines	Lunch in Pines	Lunch in Pines	Lunch in Pines
13:30					
13:45					
14:00	FREE	FREE	FREE	FREE	FREE
14:15				General Atomics tour (meet in plaza outside auditorium at	
14:30	Workshops Auditorium: Hydrodynamic	Workshops Auditorium: Hydrodynamic	IFE economics / Balance of plant		Career Panel GA (Manuel) ASML (Hahn)
14:45					
15:00					
15:15					

15:30	modeling [Tzeferacos, Golovkin] Malamud: machine learning [Knapp, Simpson] Deutz: kinetic modeling [Tsung, Arefiev]	modeling [Tzeferacos, Golovkin] Malamud: machine learning [Knapp, Simpson] Deutz: kinetic modeling [Tsung, Arefiev]	[Woodruff] (14:30-14:50) Fusion Fuel Cycles + Blankets [Garcia-Diaz, Babineau] (14:50-15:10) Computing for IFE [Vay or Huebl] (15:10-15:30) BREAK (15:30-15:45) Excimer Laser + LPI Mitigation [Bates] (15:45-16:05) Broad bandwidth laser + Direct Drive [Zuegel] (16:05-16:35) Public Perception / Energy Equality [Ripberger, Gupta] (16:35-17:05) Open Discussion (17:05-17:30)	2:15; look for Mario) OR UCSD walking tour (meet in plaza outside auditorium at 2:30; look for Mathieu)	University (Tzeferacos, Arefiev) Labs (Merritt, Mariscal)
15:45					
16:00					FREE
16:15					
16:30					
16:45					
17:00					
17:15					
17:30	FREE	FREE	FREE		
17:45					
18:00					Closing Reception at Dirty Birds
18:15					
18:30	Dinner in Pines	Dinner in Pines	Dinner in Pines	Dinner in Pines	
18:45					
19:00					
19:15					
19:30					

19:45					
20:00					

Poster Session (*List alphabetized by last names)*

First Name	Last Name	Abstract Title
Tristan	Bachmann	Modeling Gravitational Landau Damping and Effective Dissipation in Collisionless Self-Gravitating Systems
Sean	Barrett	Multi-group Eulerian Radiation Transport, Nuclear Burn with α Particle Transport, and new diagnostic features for First Light's multi-physics ICF code – B2
Alemayehu	Bogale	Laser-Based MeV X-ray Radiographic Imaging for HEDS and Applications
Dzafer	Camdzic	Enhancing XUV Generation with Focal Cone High Harmonic Geometry in High Energy Density Plasma Diagnostics
Veronica	Contreras	Measuring Coulomb Explosion Ions from OMEGA EP Interactions
Ronak	Desai	Applying Machine Learning Methods to Laser Acceleration of Protons: Lessons Learned from Synthetic Data
Ben	Duhig	Simulating anisotropic radiation fields using variable Eddington factors.
Tucker	Evans	Investigating Multi-Ion and Kinetic Physics in Shock- and Ablatively-Driven Implosions at Omega
William	Gammel	Optimization of Cylindrical Target Designs via Gaussian Process Surrogate Modeling.
John	Gjevre	Enhancing XUV Radiation for HED Plasma Diagnostics via Focal Cone High Harmonic Generation
Jesse	Griff-McMahon	Absolute Measurement of Biermann-Battery Magnetic Fields in HED Plasmas Using Proton Deflectometry and X-Ray Fiducials at OMEGA
Haritha	Hariharan	Modeling Magnetic Field Effects on Atomic States and Line Emission in High-Field Plasmas
Charlie	Heaton	Exploring Transport Properties in Extreme Conditions Using X-ray Photon Correlation Spectroscopy
Yves	Heri	Space charge effects on short pulses beam profile
Kimberly	Inzunza	Collisionality studies of supersonic plasma jets on a 500 kA, 160 ns Linear Transformer Driver
Min Ki	Jung	Interaction between a collisionless coronal plasma and a high intensity laser beam
Alexey	Knyazev	On stochastic laser dynamics in colliding laser beams
Thomas	Kosteletos	Mode-1 Perturbations of Multi-Shell ICF Volume Ignition Implosions
Joshua	Latham	Experiments measuring magnetic fields of laser-driven plasmas
Kirill	Lezhnin	Benchmarking and first results of particle-in-cell simulations with laser energy deposition module
David	Michta	Modeling the CESZAR Gas-Puff Z-Pinch in the FLASH code

Kasper	Moczulski	FLASH Simulations for the Redesign of the OMEGA TDYNO Experimental Platform
Ananya	Mohapatra	Unit testing the extended MHD capabilities in the FLASH code
Philip	Moloney	Simulations of Cross-Beam Energy Transfer in Cylindrical Directly-Driven Targets
Joanna Piper	Morgan	Exploration of the one cell inversion iteration scheme for the solution of the time-dependent Neutron Transport Equation (NTE)
Jan	Nikl	Multi-physics Lagrangian MHD code based on high-order finite elements
Tanner	Nutting	Active beam pointing control in the zettawatt-equivalent ultrashort pulse laser system (ZEUS)
Emily	Rettich	Steep density gradients observed in filamented, counter-streaming beryllium plasma
Lucas	Rovige	Experimental study of magnetic reconnection in laser-driven ion-scale magnetospheres on the Large Plasma Device (LAPD)
Jang Hyeob	Sohn	Free-free opacity calculation model of FLYCHK and generated opacities of various materials(Al, Au, H)
Farhana	Taiyebah	Exploring the Multi-physics Complexity in Thermonuclear Supernova Explosions: Insights from Cross-Correlations and Analysis
Yuji	Takagi	Multivariate scaling of maximum proton energy in intense laser driven ion acceleration
Divya	Tank	An Introduction to First Light Fusion's Projectile Driven ICF
Bingqing	Wang	Transmission Line Modeling and Statistic Analysis of Nanoscale Tunneling Electrical Contacts
Jaela	Whitfield	Filament Shape Characterization on NSTX
Christopher	Wink	The MRS-upgrade (MRSu) design in replacement of the current MRS on OMEGA

Short Talks (*List alphabetized by last names)*

First Name	**Last Name**	**Abstract Title**
Andre	Antoine	Machine Learning for Laser Wakefield experimental diagnostics
Kelsey	Adler	A statistical approach to Stark broadening for complex ions
Rebecca	Fitzgarrald	Laser wakefield acceleration, single-shot diagnostic techniques used to obtain the betatron X-ray spectrum
Haritha	Hariharan	Magnetic Field Effects on Atomic States and Line Emission in Plasmas
Charlie	Heaton	Measurement of transport coefficients in dense plasma using X Ray Photon Correlation Spectroscopy
Luisa	Izquierdo	Shock interactions between laser-produced plasma and jets emitted from conical wire array z-pinches

Nic	Mitchell	Non-local effects on plasma transport quantities of interest in inertial confinement fusion (ICF)
Claudia Camila	Parisuana Barranca	Computational Fluid Dynamic Modeling of Droplets Heated by an X-ray Free Electron Laser using PISALE code
Ryan	Revolinsky	Investigations on the of Dual-Frequency Harmonic Magnetically Insulated Line Oscillator
Brendan	Stassel	Investigating Relativistic Transparency in ultrafast high intensity laser plasma interactions
Radka	Stefanikova	X-ray spectroscopy measurements at DRACO PW laser facility
Edna Rebeca	Toro Garza	Measuring the conductivity of laser-excited water using a single-shot terahertz (THz) time-domain spectroscopy
Thomas	Varnish	Using Exploding Wire Arrays to Study Pulsed-Power-Driven Guide-Field Magnetic Reconnection
Sameen	Yunus	Average Atom Models for Warm Dense Matter as a DFT Embedding Theory Problem

List of Supported Students (*List alphabetized by last names)*

First Name	Last Name	Research Area
Kelsey	Adler	Lineshapes, Stark effect and line-broadening
Daniel	Alex	ICF, Turbulence and Transport
Andre	Antoine	Short Pulse Laser Plasma and Machine Learning
Tristan	Bachmann	Computational Astrophysics
Sean	Barrett	Inertial Confinement Fusion
Alemayehu	Bogale	Laser Plasma Instabilities, Lab Astrophysics, Particle Acceleration
Precious	Cantu	HED/ICF Diagnostics
Veronica	Contreras	Intense Laser-Plasma Interactions
Ronak	Desai	Computational Plasma Physics
Ben	Duhig	Radiation Hydrodynamics
Tucker	Evans	Inertial Confinement Fusion
Rebecca	Fitzgarrald	Laser wakefield acceleration
William	Gammel	Inertial Confinement Fusion / Machine Learning
John	Gjevre	Photonics and Plasmas
Jesse	Griff-McMahon	Magnetic Reconnection and Proton Radiography
Haritha	Hariharan	High Energy Density Physics
Charlie	Heaton	Transport in dense plasmas
Yves	Heri	Computational plasma, laser-plasma interaction and space-charge-limited current flows
James Edward	Hernandez II	High Energy Density Physics, ICF
Franklin	Ho	Mechanical Engineering & Engineering Physics
Luisa	Izquierdo	Plasma Physic -Laboratory astrophysic
Min Ki	Jung	Plasma physics
Mara	Klebonas	HEDLP
Thomas	Kosteletos	ICF
Joshua	Latham	High-intensity laser-plasma physics
Kirill	Lezhnin	Laser-plasma interactions, EUV source simulations
James	McLoughlin	Laser development and HED
Nic	Mitchell	Transport in ICF plasmas
Kasper	Moczulski	Computational HEDP
Ananya	Mohapatra	Magnetohydrodynamic Turbulence, Laser-driven hydrodynamics and shocks
Philip	Moloney	Direct Drive ICF

Joanna Piper	Morgan	radiation transport methods on accelerated hardware (Monte Carlo and deterministic)
Jan	Nikl	laser plasma physics, hydrodynamics, numerical modeling
Tanner	Nutting	Laser wakefield acceleration
Claudia Camila	Parisuana Barranca	Laser-driven hydrodynamics and shocks
Emily	Rettich	Plasma Physics
Ryan	Revolinsky	Non-neutral plasmas, pulsed power, high power microwaves
Keenan	Riordan	Laboratory Astrophysics
Lucas	Rovige	Magnetized plasmas and colisionless shocks
Nicholas	Ruof	High Energy Density Physics
Jang Hyeob	Sohn	High energy density physics
Brendan	Stassel	Ultrafast Laser Plasma Interactions
Radka	Stefanikova	x-ray spectroscopy in short-pulse solid-density laser-plasmas
Landon	Tafoya	HEDP/ICF Diagnostics
Farhana	Taiyebah	Plasma Turbulence
Yuji	Takagi	Laser plasma,PIC
Divya	Tank	Inertial Confinement Fusion
Edna Rebeca	Toro Garza	High Energy Density Science
Isobel	Turner-Wilson	ICF
Thomas	Varnish	Pulsed-Power Lab Astro
Bingqing	Wang	Novel Plasma and Vacuum Electronic
James	Welch	Strongly Magnetized Plasmas
Jaela	Whitfield	ICF- Shock compressions
Christopher	Wink	ICF diagnostics
Hong	Yang	Condensed matter physics, Planetary interiors
Nazifa	Younus	atomic physics in plasmas
Sameen	Yunus	HEDP theory/simulations