UNIVERSITY of ROCHESTER

LABORATORY FOR LASER ENERGETICS

2018 SUMMER HIGH SCHOOL STUDENT RESEARCH PRESENTATIONS

Wednesday, 29 August 2018
LLE Coliseum

1:30–1:35	Welcome	Dr. R. S. Craxton
1:35–1:45	Presentation of the 2018 William D. Ryan Inspirational Teacher Award	Dr. E.M. Campbell
1:45–2:00	Introduction	Audrey DeVault
2:00–2:12	Measurement Accuracy of the Harmonic Energy Diagnostic on OMEGA EP	Aditya Bhargava
2:12–2:24	Investigations of the Hydrogen-Palladium and Deuterium-Palladium Systems	Katie Glance
2:24–2:36	Real-Time X-ray Analysis of Liquid-DT Fill Level in Fill-Tube Capsules to Control Final Solid-Layer Thickness	Carwyn Collinsworth
2:36–2:48	Oxidation of Hydrogen over Copper Zinc Alloy	Maia Raynor
2:48–3:00	Optimization of Cone-in-Shell Targets for an X-ray Backlighter on the National Ignition Facility	Anirudh Sharma
3:00–3:12	Microscopy with Ultraviolet Surface Excitation in Life Science Education	Katie Kopp
3:12–3:30	Break	
3:30–3:42	Evaluation of Neutron Time-of-Flight Spectra from Deuterium-Deuterium Fusing Plasmas in Inertial Confinement Fusion on OMEGA	Audrey DeVault
3:42–3:54	A Containerized Approach for Data Analysis on Omega	Aidan Sciortino
3:54–4:06	Computational Chemistry Modeling of Photoswitchable Liquid Crystal Alignment Materials	Hannah Lang
4:06–4:18	Complex Ray Tracing and Cross-Beam Energy Transfer for Laser-Plasma Simulations	Alan Tu
4:18–4:30	Protective Polymer Coatings for Laser Optics	Margaret Rudnick
4:30–4:42	Modeling Charged-Particle Spectra to Diagnose Asymmetries in OMEGA Implosions	Matthew Cufari
4:42–4:54	Current Characteristics of Pulse-Forming Networks Driving High-Energy Flash Lamps	Steven Booth
5:00–5:40	Tour of the OMEGA and OMEGA EP lasers	Mark Labuzeta, David Canning

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Measurement Accuracy of the Harmonic Energy Diagnostic on OMEGA EP

Aditya Bhargava
Victor Senior High School
LLE Advisor: Mark Guardalben

The Harmonic Energy Diagnostic on OMEGA EP uses integrating spheres to measure the infrared, green, and ultraviolet laser beam energies. Measurement errors can arise when light escapes through the laser beam entrance port of the sphere. A MATLAB model was developed to calculate how the laser flux escaping through the entrance port changes with incident angle of the laser beam and diameter of the integrating sphere. The model shows that energy measurements are less sensitive to changes in laser beam incident angle for larger diameter spheres and smaller incident angles. The results suggest that the baffle in the integrating sphere, which prevents unwanted stray light from contributing to the measurement, may contribute significantly to the measurement error owing to its high angle of incidence and close proximity to the entrance port.

Investigations of the Hydrogen-Palladium and Deuterium-Palladium Systems

Katie Glance
Pittsford Sutherland High School
LLE Advisors: Walter Shmayda and Matthew Sharpe

Palladium is a metal that reacts with hydrogen and its isotopes to form palladium hydride below 610 K. Palladium absorbs a significant amount of hydrogen within its crystal lattice and can act as a storage medium. The hydrogen-to-palladium atom ratio (H:Pd) was measured as a function of equilibrium hydrogen pressure over palladium at fixed temperatures. Data has been obtained for H:Pd and D:Pd ratios between 0.0 and 0.8 and temperatures between 293 K and 393 K. The van't Hoff plot of the present data shows consistency with literature data, regarding the standard enthalpy change ΔH and the standard entropy change ΔS. The ΔH was measured to be -36 kJ/mol and the ΔS was measured to be -143.9 J/mol*K. This experiment fills in temperature gaps and further validates prior data on the hydrogen-palladium and deuterium-palladium systems.

Real-Time X-ray Analysis of Liquid-DT Fill Level in Fill-Tube Capsules to Control Final Solid-Layer Thickness

Carwyn Collinsworth
Brighton High School
LLE Advisors: Mark Wittman and Dana Edgell

Future cryogenic-target experiments on OMEGA will fill spherical capsules with deuterium-tritium (DT) liquid through ~10-μm-diameter fill tubes. A prototype has been constructed to determine the correct filling and layering parameters. The fill level is controlled by adjusting the DT vapor pressure above the liquid via the capsule's temperature, and phase-contrast x-ray imaging is used to monitor the filling process. This has been automated by developing a MATLAB script that communicates with the camera-control software directly and with the temperature controller via a GPIB-USB interface. The program estimates the solid-DT layer thickness from the liquid meniscus, and calculates a temperature change based on the difference between the current and desired thicknesses. Once the solid-DT thickness is within ±1 μm of the desired thickness, an ice plug is formed in the fill tube by lowering the fill-tube temperature. The final solid-DT thickness is again measured, and if the desired thickness has not been met, the ice plug is melted, the thickness goal is adjusted, and the fill-adjustment process is repeated.

Oxidation of Hydrogen over Copper Zinc Alloy

Maia Raynor
Brighton High School
LLE Advisors: Walter Shmayda and Cody Fagan

A copper zinc (Cu/Zn) alloy was characterized for its use as an alternative concept to traditional techniques for extracting molecular tritium from air streams. The tritium is oxidized to form tritiated water, which is then captured on a molecular sieve. The Cu/Zn alloy consists of 40 wt% Cu and 40 wt% Zn on alumina. In this work, hydrogen is used as an isotopologue alternative to tritium to mitigate any radiological hazards. Oxygen is loaded onto the bed preceding the hydrogen oxidation. The oxygen gettering dependence on alloy temperature has been measured at various bed temperatures. Gettering capacity increases as the temperature increases from 30°C to 150°C and approaches 100% at 150°C. The conversion efficiency for hydrogen oxidation over oxidized alloy was measured at 200 °C. The conversion efficiency of hydrogen to water is 100% at 200 °C irrespective of the oxygen inventory on the bed. Using the data from this experiment, it is expected that 99.7% of the molecular tritium present in an air stream will be converted to form tritiated water.

Optimization of Cone-in-Shell Targets for an X-ray Backlighter on the National Ignition Facility

Anirudh Sharma
Webster Schroeder High School
LLE Advisor: Stephen Craxton

A double cone-in-shell plastic (CH) target has been optimized for the purpose of x-ray backlighting a hohlraum-heated iron sample in an opacity platform at the National Ignition Facility. Both the pointings of the available laser beams and various parameters of the cones have been optimized using the 2D hydrodynamics simulation code *SAGE*. By placing all the beams in best focus and appropriately selecting the pointings of the beams, a uniform implosion has been achieved. The behavior of the cone has been optimized by selecting a sufficiently small cone half-angle that laser rays do not enter the cone and a sufficiently large distance from the cone tip to the target center that the cone's obstruction of the implosion is minimal. An x-ray diagnostic code, *Orion,* has been created for the purpose of calculating the x-ray output from the targets. The optimized design has been found to produce a short (~350 ps) point source (~100 μm) of x rays, effectively eliminating emission produced by the capsule before peak compression. The selected parameters ensure that the convergence of the cone on the vertical axis prevents hot compressed plasma from escaping through the cone after peak compression.

Microscopy with Ultraviolet Surface Excitation in Life Science Education

Katie Kopp
Victor High School
LLE Advisor: Stavros Demos

This project investigates how to integrate Microscopy with Ultraviolet Surface Excitation (MUSE) into a high school science classroom in order to engage and inspire students through laboratory exercises. MUSE was initially created to assess and visualize laser damage, but has been adapted to medicine and life science. MUSE utilizes the unique property of ultraviolet light at wavelengths around 270 nm to propagate about ten micrometers into tissues, thus illuminating only the top cell layer. Ultraviolet light causes a relatively large amount of autofluorescence, and MUSE imaging relies on the visible structural differentiation caused by this fluorescence. This allows for imaging of the cellular organization and microstructure without the need to cut the sample into very thin sections. Laboratory experiments including tissue staining protocols have been developed to directly expose students to plant and animal microanatomy. These exercises enable students to identify various microstructures relating to the life science curriculum.

Evaluation of Neutron Time-of-Flight Spectra from Deuterium-Deuterium Fusing Plasmas in Inertial Confinement Fusion on OMEGA

Audrey DeVault
Penfield High School
LLE Advisor: Chad Forrest

Neutron diagnostics are essential for interpreting the plasma conditions during compression for inertial confinement fusion experiments. Flows within reacting plasmas will have an effect on the neutron energy distribution, with bulk flow velocities affecting the first spectral moment (mean) and residual kinetic energy affecting the second spectral moment (variance). A forward-fit analysis technique was developed to interpret the first and second spectral moments of a primary (DD) neutron energy distribution from a neutron time-of-flight signal. Characteristics of the fusing plasma ascertained using the developed fitting procedure can be used to diagnose both the condition of the fuel and asymmetries in the laser-target system. This technique was utilized in a campaign to measure the effect of deliberately applied laser pointing-induced modes and target offset-induced modes. Experimental results were shown to be in agreement with radiation hydrodynamic simulations.

A Containerized Approach for Data Analysis on Omega

Aidan Sciortino
Wilson Magnet High School
LLE Advisor: Richard Kidder

Scientific data analysis is critical to the work done at LLE. An important part of this is enabling easy access to data and compute resources for scientists, both on the day of a shot and afterwards. Current systems for accessing data for analysis are old, hard to access, and have long download times. This makes quick analysis between shots very difficult. This project explores possible ways to remedy this, presenting a container-based system allowing web-based development of analysis programs, with easy access to data on the webpage itself. This is part of a larger study of containerization as a way to provide compute resources across the lab, scaled according to need.

Computational Chemistry Modeling of Photoswitchable Liquid Crystal Alignment Materials

Hannah Lang
Rush-Henrietta Senior High School
LLE Advisor: Kenneth Marshall

The optical switching properties of spirooxazine in photoalignment command surfaces, used to control the molecular orientation of liquid crystals (LC), were modeled using density functional theory in order to identify the optimal molecular structure for a rewritable, photoswitchable LC beam shaper for high-peak-power lasers such as OMEGA EP. This photoswitchable device would replace existing laser beam-shaper technology, which is limited in its application scope by a low 1053-nm laser damage threshold. This work examined the effect of molecular structure on bistability (switching state lifetime) by modeling different functional groups attached to the spirooxazine chromophore, along with alkyl tethers ranging in length from 3 to 9 carbons to link the chromophore to a methacrylate polymer backbone, to find an ideal combination possessing high bistability. The most promising molecule that was modeled exhibited the smallest isomerization-state energy difference and moderately high activation energy, and its larger functional group should prove effective at redirecting the orientation of the liquid crystal materials.

Complex Ray Tracing and Cross-Beam Energy Transfer for Laser-Plasma Simulations

Alan Tu
Pittsford Sutherland High School
LLE Advisor: Adam Sefkow

A ray-tracing code has been developed that propagates laser beams by representing them as bundles of rays and then evolving the rays in time according to a set of differential equations. These equations take into account the dispersion relation and the density profile of the background plasma. The energy deposited by the beams, as well as the beam intensities and electric fields, can be calculated and plotted onto a grid. Cross-beam energy transfer (CBET), which occurs when laser beams overlap in a plasma, was implemented into the program for two interacting beams. This new program performs the CBET calculations faster than current programs in use. Furthermore, a new ray-tracing method was investigated, namely complex ray tracing, which represents a laser beam with only five rays. The results are identical to those of regular ray tracing, but are achieved faster and may model additional effects such as diffraction. In the future, this work will be implemented into the 3-D hybrid fluid-kinetic code CHIMERA.

Protective Polymer Coatings for Laser Optics

Margaret Rudnick
Pittsford Mendon High School
LLE Advisor: Kenneth Marshall

Mirrors and laser glass used in OMEGA and OMEGA EP are sensitive to water. When water vapor works its way into the pores of high-reflectance mirror coatings, the wavelength of peak reflectance shifts, leading to a reduced reflectance at the intended beam wavelength. Water exposure leads to pitting and eventually clouding on laser glass, causing light from the laser beam to scatter. Both of these effects ultimately lead to a loss of energy as the beam makes its way to the target. Different organosilanes and coating processes were tested on both mirrors and laser glass with the overall goal of slowing the absorption of water into the samples. An effective coating process was found for the mirrors that involves vapor depositing organosilanes after purging the sample with nitrogen. Vapor depositing organosilane coatings onto laser glass did not afford a sufficient level of protection from water vapor, but polydimethylsiloxane (PDMS) was found to effectively protect the glass from water damage in an environment of 99% relative humidity.

Modeling Charged-Particle Spectra to Diagnose Asymmetries in OMEGA Implosions

Matthew Cufari
Pittsford Sutherland High School
LLE Advisors: Radha Bahukutumbi and Owen Mannion

Charged-particle spectra are used to diagnose implosion asymmetries on OMEGA. These asymmetries can be the result of numerous imperfections including beam mispointing, beam mistiming, and target offset, and manifest as variations in the areal density of the target. For room temperature D_2 shots, the areal density can be inferred from the average energy of detected secondary protons. Asymmetries can then be inferred by comparing areal density measurements along multiple lines of sight. The Monte-Carlo code IRIS3D has been extended to simulate secondary protons from D_2 targets and knock-on deuterons from DT targets. IRIS3D generates energy spectra for secondary protons and knock-on deuterons by simulating the reactions in an ICF implosion. IRIS3D then computes the average energy along multiple lines of sight to infer areal density asymmetries around the target. By postprocessing hydrodynamic simulations with IRIS3D, direct comparisons can now be made with experimental data to infer areal density asymmetries.

Current Characteristics of Pulse-Forming Networks Driving High-Energy Flash Lamps

Steven Booth
Brighton High School
LLE Advisors: Wade Bittle, Vinitha Anand

High-intensity flash lamps are used to excite laser glass amplifiers on the OMEGA and OMEGA EP lasers. These lamps are driven by high-energy current pulses created by pulse-forming networks in power conditioning units (PCU's). There are many components in the flash lamp and PCU driver systems and, because of this, degradation and failures can occur. In order to help determine when preventative maintenance is required, two programs were developed that analyze PCU diagnostic current data. The first program calculates summary metrics from the current data stored after each shot in the power conditioning database and compiles them into excel files. With these files, the second program can display useful information on a per-shot basis and summary metric trends over time.