UNIVERSITY of ROCHESTER

LABORATORY FOR LASER ENERGETICS

2017 SUMMER HIGH SCHOOL STUDENT RESEARCH PRESENTATIONS

Wednesday, 30 August 2017
LLE Coliseum

1:30–1:35	Welcome	Dr. R. S. Craxton
1:35–1:45	Presentation of the 2017 William D. Ryan Inspirational Teacher Award	Dr. R. S. Craxton
1:45–2:00	Introduction	Matthew Galan
2:00–2:13	Studying the Hydrogen-Palladium System at Low Temperatures	Griffin Cross
2:13–2:26	Improving the Uniformity of *Revolver* Designs for the National Ignition Facility	Yujia Yang
2:26–2:39	Characterization and Detection of the Deterioration of Electrical Connectors in a Flash-Lamp System	Meshach Cornelius
2:39–2:52	Analysis of Asymmetries of the Hot Spot Using Synthetic X-Ray Images	Claire Guo
2:52–3:05	Ion Temperature Analysis of Neutron Time-of-Flight Data	Viknesh Baskar
3:05–3:25	Break	
3:25–3:38	Modifying Stainless Steel Surfaces by Electropolishing	Arian Nadjimzadah
3:38–3:51	Predetermination of DT Fuel Mass in Cryogenic Target Capsules from Any Viewing Angle	Jonathan Moore
3:51–4:04	Data Services for Scientific Analysis on OMEGA and OMEGA EP	Matthew Galan
4:04–4:17	Compensation for Self-Focusing on OMEGA EP by Use of Frequency Conversion	Nikhil Bose
4:17–4:30	Ambient-Temperature Ammonia Removal Process for Sol-Gel Coating Solutions	Joyce Luo
4:30–4:43	Modeling and Analysis of Cherenkov Radiation Detectors	Benjamin Chaback
4:50–5:30	Tour of the OMEGA and OMEGA EP lasers	

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Studying the Hydrogen-Palladium System at Low Temperatures

Griffin Cross
Pittsford Sutherland High School
LLE Advisor: Walter Shmayda

Palladium is a metal which has been found to absorb hydrogen at low temperatures and to compress hydrogen and its isotopes to high pressures at modest temperatures. An experimental setup comprising a palladium getter connected to a hydrogen distribution loop was used to measure the hydrogen pressure over palladium hydride as a function of the hydrogen-to-palladium (H/Pd) atom ratio and palladium-hydride temperature. Equilibrium hydrogen pressures at palladium-hydride temperatures below 273 K are not available in the open literature. Equilibrium pressures have been measured for H/Pd ratios between 0.0 and 0.8 and temperatures between 123 K and 293 K. This extends the prior minimum temperature of study from 293 K down to 123 K and expands the upper bound of the H/Pd ratio studied from 0.6 to 0.8.

Improving the Uniformity of Revolver *Designs for the National Ignition Facility*

Yujia Yang
Brighton High School
LLE Advisor: Stephen Craxton

The proposed *Revolver* target, consisting of nested beryllium, copper, and gold shells, is an alternative (with a 2x radius) to the conventional target for implosions on the National Ignition Facility (NIF). A new design has been developed for *Revolver* using custom phase plates (optics that set the size of the focal spot), since the maximum allowed defocus of current NIF phase plates produces focal spots that are too small, leading to significant nonuniformity in the azimuthal direction. This work considered variations of the size and ellipticity of the beams and their intensity profiles and pointings. The new design, developed using the 2D hydrodynamics simulation code *SAGE*, optimizes the NIF beam parameters to decrease the overall nonuniformity by a factor of 1.25 and to reduce the azimuthal nonuniformity by more than two-fold.

Characterization and Detection of the Deterioration of Electrical Connectors in a Flash-Lamp System

Meshach Cornelius
Gates Chili High School
LLE Advisors: Troy Walker and Greg Brent

On OMEGA and OMEGA EP, high-intensity flash lamps are used to excite the laser glass amplifier medium. A continuous flow of high resistance deionized water around the flash lamps is used to keep the lamps cool. When electrical current travels through the connections, a small amount of metal is displaced. In the long-term, this continuing release of material causes flash-lamp failure. To remedy the problem, the concept of a non-invasive process to detect the level of flash-lamp connector deterioration was developed and tested. This involves analyzing changes in the resistance of the water flowing through the flash-lamp cooling system. The resistance shows a drop due to the presence of metal in the water. Flash-lamp systems at different stages of degradation were tested. It was found that the change in resistance is correlated to the level of deterioration in the flash-lamp connectors. This research will allow the state of the connectors to be monitored and will ensure that the connectors are replaced before flash-lamp failure.

Analysis of Asymmetries of the Hot Spot Using Synthetic X-Ray Images

Claire Guo
Penfield High School
LLE Advisors: Arijit Bose, Reuben Epstein

In inertial confinement fusion (ICF) implosions, self-emission x-ray images are used to estimate the properties of the hot spot. The asymmetry modes present in the hot spot and their amplitudes can be inferred using these images. Both time-integrated and time-resolved images can be obtained from cryogenic implosion experiments at OMEGA. These images are analyzed for the detection of long- and mid-wavelength asymmetries by comparison with synthetic images obtained from hydrodynamic simulations. The deceleration phase is simulated using the hydrodynamic code *DEC2D*, followed by post-processing using the atomic physics code *SPECT3D* to produce the synthetic images. From the synthetic images, it is found that the time evolution of the radius and shape of the image differs for implosions with low- and mid-mode asymmetries. This can be used to infer the modes present in the implosions.

Ion Temperature Analysis of Neutron Time-of-Flight Data

Viknesh Baskar
Webster Schroeder High School
LLE Advisors: Chad Forrest, James Knauer

Neutron spectroscopy is a critical diagnostic technique to measure the target performance in ICF cryogenic D-T direct-drive implosions. At the OMEGA laser facility, the energy spectrum is measured utilizing a neutron time-of-flight spectrometer located 5.0 m from the target chamber center. The spectrometer uses a chemical-vapor-deposition diamond detector which has a well characterized instrument response function. A nonlinear-least-squares forward-fit approach was constructed to infer the average ion temperature from the experimental data. The model was developed by convolving the non-relativistic fusion-neutron energy distribution with the measured instrument response function. An optimal least-squares fit was achieved by testing various amplitude, mean, and variance parameters.

Modifying Stainless Steel Surfaces by Electropolishing

Arian Nadjimzadah
Brighton High School
LLE Advisor: Walter Shmayda

Tritium ingress into stainless steel depends on the surface characteristics of the metal. Electropolishing provides a flexible and controllable method of modifying a metal surface by reducing the surface roughness. A program has been implemented to study the dependence of surface roughness on electrolytic current density, overpotential, electrolyte composition, polishing time and operating conditions such as temperature and stir rate. Multiple plots of current density versus potential have been generated at different temperatures as a first step in establishing the appropriate operating electrolytic conditions for a given operating situation. A variety of operating conditions have been tested to obtain a smoother surface and mitigate surface thickness loss. The precise formation of a viscous layer and the control of gas evolution on the surface have been paramount in developing a macroscopically and microscopically smoother finish.

Predetermination of DT Fuel Mass in Cryogenic Target Capsules from Any Viewing Angle

Jonathan Moore
Pittsford Sutherland High School
LLE Advisors: Mark Wittman, Adam Kalb

Future OMEGA experiments will use spherical capsules filled via a fill tube as targets. Such a capsule is first cooled to cryogenic temperatures and filled with a liquid deuterium-tritium (DT) mixture, which is then solidified to produce a uniformly thick DT layer prior to being imploded. Before solidification, most of the liquid DT pools at the bottom of the capsule. Phase-contrast x-ray imaging is used to observe the DT liquid. When the x-ray camera is placed normal to the direction of gravity, determination of the fuel mass from an image of the liquid stage is straightforward because of symmetry about the vertical axis, making it possible to fill the capsule with the desired amount of fuel. Due to the placement of other equipment on the OMEGA target chamber, such a location for the camera is impossible. A MATLAB code was developed to provide a template for a given final fuel-layer thickness with the viewing axis at any angle with respect to gravity. The capsule is filled with DT until the real-time x-ray image matches the template. The code has also been used to determine the optimal camera position.

Data Services for Scientific Analysis on OMEGA and OMEGA EP

Matthew Galan
Fairport High School
LLE Advisor: Richard Kidder

A data service was developed that allows scientists to easily incorporate data from experiments on the OMEGA and OMEGA EP lasers into their data analysis programs. This data service replaces the previous method of manually copying and pasting from a static report page, which was prone to error and slow, or querying the database with the programming language SQL, which was inconvenient. The data service allows scientists to automatically incorporate large amounts of data into their data analysis programs, including MatLab, Python, and Jupyter. This makes data retrieval more accessible for both internal and external scientists. Authentication was also integrated into the data service, providing protection from unauthorized or malicious users.

Compensation for Self-Focusing on OMEGA EP by Use of Frequency Conversion

Nikhil Bose
Pittsford Sutherland High School
LLE Advisor: Mark Guardalben

Shots on the short-pulse beamlines of OMEGA EP are limited to below their maximum design energy in order to prevent laser-induced damage to many optical components in the laser system. For 100-ps on-target pulse widths, high beamline intensities produce small-scale self-focusing in the beam caused by the intensity-dependent refractive index and resulting nonlinear (B-integral) phase. A MATLAB model was developed to explore the use of frequency conversion to partially cancel the accumulated B-integral phase. A frequency conversion crystal, cut for type-I second harmonic conversion, was detuned such that as the beam goes through the crystal it is converted to the second harmonic (green) and then back to the fundamental (infrared) with a change of phase. Using this model, a 4.5-cm DKDP crystal, placed between the booster amplifiers and the transport spatial filter, reduces the peak-to-mode modulation by 8% at the compressor vacuum window, 9% at the first grating, and 10% at the off-axis parabola, while also maximizing the output infrared energy. This suggests that it might be possible to increase the on-target energy limit by up to 7% for 100-ps shots.

Ambient-Temperature Ammonia Removal Process for Sol-Gel Coating Solutions

Joyce Luo
Pittsford Mendon High School
LLE Advisor: Ken Marshall

The current sol-gel preparation process utilizes refluxing (boiling of a solution with condensation of the solvent) to remove the ammonia catalyst and halt the formation of a rigid silica-oxide network. This process requires specialized glassware, cooling water, and a controlled heat source, all of which require precise control and frequent monitoring. Removal of the ammonia by bubbling a gas into the solution (purging) significantly simplifies the process and eliminates the need for a heat source. In this work, the ability to displace ammonia dissolved in 2.5 L of ethanol by purging using three inert gases (argon, helium, and nitrogen) was evaluated at a flow rate of 4 L/min in a simple setup to assess the new process efficiency versus refluxing. Similar ammonia removal rates were observed for all three gases (~24 hrs to reduce the solution pH from 11 to 7). The purge process was successfully applied to remove ammonia from a 2.5 L batch of production sol-gel solution in 24 to 42 hrs with minimal effort and attention.

Modeling and Analysis of Cherenkov Radiation Detectors

Benjamin Chaback
Byron-Bergen High School
LLE Advisors: James Knauer and Chad Forrest

A Cherenkov radiation detector was designed that allows the width of the response function from neutron time of flight experiments to be reduced, resulting in more accurate measurements of neutrons from deuterium-tritium fusion. Cherenkov radiation occurs when a particle travels faster than the speed of light in a medium, creating a cone of emission in the direction of particle motion. The width of the neutron spectrum is used to find the temperature of the plasma, which must be known to a high degree of accuracy. The detector consists of a reflective mirror mounted to the end of a PVC elbow connector, a reflective cone inside the detector, and a microchannel-plate photomultiplier tube on the bottom of the detector. The detector housing is made of schedule 80 PVC, a material that can be made light tight and does not reflect neutrons or muons. The modeling of this detector was done using CAD software (OnShape) and the expected outputs from the detector were simulated using the Monte Carlo code NRESP7. A detector has been manufactured and is undergoing preliminary testing.