UNIVERSITY of ROCHESTER

LABORATORY FOR LASER ENERGETICS

2021 SUMMER HIGH SCHOOL STUDENT RESEARCH PRESENTATIONS

Wednesday, 11 August 2021

Zoom: https://rochester.zoom.us/j/91333197520?pwd=d3JYU0xYSlZadFdjN0pic2xjem1xdz09

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2:10–2:25	Development of a Polar-Direct-Drive Design for a Large-Diameter Beryllium Target on the National Ignition Facility	Tyler Petrillo
2:25–2:40	Data Services to Improve Access to Scientific Image Data	Leo Sciortino
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2:50–3:05	Polar-Direct-Drive Designs for the Laser Megajoule	Audrey Kohlman
3:05–3:20	Computational Modeling of the Polarizability of Liquid Crystals	Andrew Wu
3:20–3:35	Optimization of Direct Drive Designs for a Proposed Dual Direct/Indirect Drive Laser	Meghan Marangola
3:35–3:50	Exploration of Collision Models for Hybrid Fluid-Kinetic Simulations	Aditya Srinivasan

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250 East River Road
Rochester, New York 14623–1299
(585) 275-5101

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Inferring a Neutron Yield from Nuclear Activation Techniques

Semma Alfatlawi
Victor Senior High School
LLE Advisor: Chad Forrest

Nuclear measurements are essential for studying implosion experiments that generate fusion reactions. One approach to inferring a neutron yield is to measure the time-integrated deuterium-deuterium (DD) fusion reaction with neutron-induced activation of indium isotopes. In this approach, the neutron yield is calculated based on the gamma ray spectrum that results from the de-excitation of indium 115. 336-keV gamma rays, from the reaction channel ^{115}In(n,n')^{115m}In, were counted using a high-purity germanium (HPGe) detector. Another DD fusion reaction with an equal branching ratio produces a proton yield that was used to determine a cross-calibration factor for the HPGe detector. A lower limit on the nuclear yield and the detector measurement uncertainty were determined for the HPGe diagnostic. These results have enabled nuclear yields for indium activated shots to be corrected in the Omega Nuclear database.

Development of a Polar-Direct-Drive Design for a Large-Diameter Beryllium Target on the National Ignition Facility

Tyler Petrillo
Webster Schroeder High School
LLE Advisor: Stephen Craxton

A laser pointing design was developed for a planned experiment on the National Ignition Facility (NIF) that will use a 4.5-mm beryllium target. The NIF laser consists of 192 beams, divided amongst 48 quads of four beams each, located in four rings in each hemisphere at angles of 23.5º, 30.0º, 44.5º, and 50.0º from the vertical. Since the NIF is configured for indirect drive experiments, a method known as polar direct drive repoints the beams away from the center of the target for direct drive experiments. The 2D hydrodynamics simulation code *SAGE* was used to optimize the NIF beam parameters in order to maximize the uniformity of the target's implosion. Additional simulations, carried out for a recent NIF shot in which the plastic target had substantial thickness variations, indicate that such variations can greatly increase the implosion nonuniformity.

Data Services to Improve Access to Scientific Image Data

Leo Sciortino
School of the Arts
LLE Advisor: Richard Kidder

HDF (Hierarchical Data Format) format has been historically used by LLE to store scientific images and their attributes. HDF images are currently stored on a file server, with files indexed through LLE's relational Oracle database. This investigation explored technologies to provide easy and secure access to image data, minimizing the need for database and file system interactions by the user. The project focused on image parsing, storage, and retrieval mechanisms for multiple formats including HDF4, HDF5, TIFF, and JSON. Services to provide some data processing (e.g., background subtraction) were also investigated. Project software was tested using Python, NodeJS, PL/SQL, and an Oracle database. Overall, the research found that using Python and its associated libraries in conjunction with web services is a viable option for presenting and processing image data.

Polar-Direct-Drive Designs for the Laser Megajoule

Audrey Kohlman
Churchville-Chili Senior High School
LLE Advisor: Stephen Craxton

The Laser Megajoule (LMJ) is a French laser facility under construction that is configured for indirect drive implosions. This configuration includes two rings of quads in each hemisphere that are positioned at either 33.2° or 49.0° from the vertical axis. There are four beams in a quad and ten quads within each ring, giving a total of 160 beams. Following a user proposal to perform direct drive implosions on the LMJ with 1000-μm-radius targets, simulations using the program *SAGE* were run to optimize the implosion uniformity; beams were repointed in the θ (longitudinal) and φ (latitudinal) directions and the quads were defocused. When user experiments begin in 2024, only half of the beams will be available. The repointings in the φ direction are essential to compensate for the missing beams. These simulations achieved implosions with low velocity nonuniformities of approximately 2% rms. Simulations of the full LMJ resulted in even lower nonuniformities of below 1% rms. This demonstration of the feasibility of direct drive on the LMJ is expected to be applicable to a variety of experiments.

Computational Modeling of the Polarizability of Liquid Crystals

Andrew Wu
Pittsford Mendon High School
LLE Advisor: Kenneth Marshall

Using the molecular modeling package *Maestro*, several liquid crystals (LCs) commonly used in laser systems were modeled computationally to achieve the lowest energy state. The difference in polarizability between the parallel and perpendicular axes of an LC molecule ($\Delta\varepsilon$) was calculated and compared to existing experimental data to determine the validity of the model. For the LC 5CB, agreement between experimental and calculated values for $\Delta\varepsilon$ was within 20%. This model can be used for future design efforts to develop LC materials with large $\Delta\varepsilon$, fast response, and high laser damage resistance for current and future applications in OMEGA and OMEGA EP.

Optimization of Direct Drive Designs for a Proposed Dual Direct/Indirect Drive Laser

Meghan Marangola
Brighton High School
LLE Advisor: Stephen Craxton

This work investigates the possibility of amending the design of the proposed SG4 laser to allow for direct drive. Chinese scientists have proposed the SG4 laser, which is configured for indirect drive and uses a spherical hohlraum rather than a cylindrical hohlraum. The SG4 target chamber uses 48 quads, each comprised of four laser beams; beams enter the hohlraum through six laser entrance holes. In the amended design, minor changes are made to beam port locations and the laser beam pointings are adjusted for direct drive. The 2-D hydrodynamics simulation code *SAGE* was used to optimize the pointings. Various beam spatial profiles and radii were investigated. Designs were found with nonuniformity values as low as ~0.57% (rms), which are comparable to simulations for a similar system (UFL-2M) proposed by Russian scientists. Tuning scans provide a preliminary estimate of the required system pointing accuracy. These results show that the amended design promises high-quality spherical direct drive implosions.

Exploration of Collision Models for Hybrid Fluid-Kinetic Simulations

Aditya Srinivasan
Pittsford Sutherland High School
Advisors: Adam Sefkow, Michael Lavell

Electrical conductivity and stopping power are important properties of plasmas such as those in Inertial Confinement Fusion. A 3D kinetic electromagnetic particle-in-cell method within the hybrid fluid kinetic code *TriForce* was used to calculate these properties. A strong electric field was first applied to a neutral copper plasma in thermodynamic equilibrium, with temperature and charge state given by the average atom model. The initial electron acceleration and subsequent slowing down due to Coulomb collisions was used to calculate the conductivity. Next, a monoenergetic beam of electrons was initialized within an aluminum plasma and the stopping power was determined from the change in beam kinetic energy over time. Calculations were shown to be in good agreement with published theoretical predictions showing that the numerical methods in *TriForce* accurately capture the physics of Coulomb interactions. These proof-of-principle calculations indicate that *TriForce* can be used to calculate the conductivity and stopping power for other materials both in and out of equilibrium.