LLE Review Quarterly Report



Contents

IN BRIEF	iii
Inertial Confinement Fusion	
High-Yield Polar-Direct-Drive Fusion Neutron Sources at the National Ignition Facility	1
Unabsorbed Light Beamlets for Diagnosing Coronal Density Profiles and Absorption Nonuniformity in Direct-Drive Implosions on OMEGA	5
Mitigation of Mode-One Asymmetry in Laser-Direct-Drive Inertial Confinement Fusion Implosions	8
High-Energy-Density-Physics Measurements in Implosions Using Bayesian Inference	11
Ionization State and Dielectric Constant in Cold Rarefied Hydrocarbon (CH) Plasmas of Inertial Confinement Fusion	13
PLASMA AND ULTRAFAST PHYSICS	
Cross-Beam Energy Transfer Saturation by Ion Heating	16
Thresholds of Absolute Two-Plasmon–Decay and Stimulated Raman Scattering Instabilities Driven by Multiple Broadband Lasers	19
Temporal Reflection and Refraction of Optical Pulses Inside a Dispersive Medium: An Analytical Approach	22
High-Energy-Density Physics	
Equation of State, Sound Speed, and Reshock of Shock-Compressed Fluid Carbon Dioxide	26
Carbon-Doped Sulfur Hydrides as a Room-Temperature Superconductor at 270 GPa	29
Unraveling the Intrinsic Atomic Physics Behind X-Ray Absorption Line Shifts in Warm Dense Silicon Plasmas	32

DIAGNOSTIC SCIENCE AND DETECTORS

A Transmitted-Beam Diagnostic for the Wavelength-Tunable UV Drive Beam on OMEGA	35
Reconstructing Three-Dimensional Asymmetries in Laser-Direct-Drive Implosions on OMEGA	39
Application of an Energy-Dependent Instrument Response Function to the Analysis of Neutron Time-of-Flight Data from Cryogenic DT Experiments	42
The Scattered-Light Time-History Diagnostic Suite at the National Ignition Facility	46
LASER TECHNOLOGY AND DEVELOPMENT	
Characterization of Partially Deuterated KDP Crystals Using Two-Wavelength Phase-Matching Angles	49
High-Efficiency, Fifth-Harmonic Generation of a Joule-Level Neodymium Laser in a Large-Aperture Ammonium Dihydrogen Phosphate Crystal	52
Dynamics of Electronic Excitations Involved in Laser-Induced Damage in HfO ₂ and SiO ₂ Films	57
LASER FACILITY	
FY21 Q1 Laser Facility Report	60
Project RemotePI: COVID-19 Mitigation-Compliant Operations on OMEGA and OMEGA EP	62
DUDI 16 MILLION AND CONTRADING DEPERTMENT	

PUBLICATIONS AND CONFERENCE PRESENTATIONS

In Brief

This volume of LLE Review 165 covers the period from October–December 2020. Articles appearing in this volume are the principal summarized results for long-form research articles. Readers seeking a more-detailed account of research activities are invited to seek out the primary materials appearing in print, detailed in the publications and presentations section at the end of this volume.

Highlights of research presented in this volume include:

- R. S. Craxton *et al.* describe polar-direct-drive exploding-pusher experiments at the National Ignition Facility (NIF). These targets are of interest as high-fluence sources of fusion neutrons (p. 1).
- D. H. Edgell *et al.* report on unabsorbed light measurements on OMEGA implosions using the 3ω gated optical imager diagnostic. The measurements are used to investigate absorption nonuniformity and coronal density profiles (p. 5).
- O. M. Mannion *et al.* use nuclear diagnostics to infer mode-one drive asymmetries in OMEGA implosions imparted by drive-beam mispointing (p. 8). A target offset was introduced to compensate the drive asymmetry and significantly improve hot-spot uniformity.
- J. J. Ruby *et al.* report on a Bayesian inference technique for inferring hot-spot plasma conditions and the corresponding uncertainties using a limited set of known parameters and a simplified physics model (p. 11).
- A. Shvydky *et al.* use density functional theory to calculate more-accurate values for the ionization state and index of refraction in the partially ionized material that is released after shock breakout (p. 13). The index of refraction is needed for inferring density profiles from interferograms of shock release taken on OMEGA EP.
- A. M. Hansen *et al.* report on measurements of cross-beam energy transfer saturation resulting from trapping-induced ion heating in TOP9 experiments (p. 16).
- R. K. Follett *et al.* use the *LPSE* code to calculate absolute thresholds for stimulated Raman scattering and two-plasmon decay driven by multiple broadband lasers at conditions relevant to OMEGA- and NIF-scale implosions (p. 19).
- J. Zhang *et al.* develop an analytic approach to calculating the reflection and transmission of light at a temporal boundary inside of a dispersive medium (p. 22).
- L. E. Crandall *et al.* report on equation-of-state measurements of CO₂ up to 800 GPa using laser-driven diamond-anvil-cell targets (p. 26).
- S. X. Hu *et al.* use density functional theory (DFT) calculations to determine stable high-pressure carbonaceous sulfur hydride compounds and to calculate their critical temperature for superconductivity (p. 29). The results are in good agreement with recent observations of room-temperature superconductivity at 270 GPa.
- V. V. Karasiev and S. X. Hu develop a novel free-energy DFT-based methodology for calculating x-ray absorption in warm dense plasmas. The new technique is used to build a first-principles opacity table for use in inertial confinement fusion (ICF) and high-energy–density physics applications (p. 32).
- J. Katz *et al.* build a transmitted beam diagnostic for diagnosing the time-resolved power spectrum of the wavelength-tunable TOP9 beam on OMEGA (p. 35).
- O. M. Mannion *et al.* develop a technique for reconstructing the hot-spot velocity, apparent ion temperature, and areal density in ICF implosions using the various neutron spectrometers on OMEGA (p. 39).

- Z. L. Mohamed *et al.* develop a forward-fitting technique for analyzing neutron time-of-flight data that includes an energy-dependent instrument response function (p. 42).
- M. J. Rosenberg *et al.* describe the progress in developing and implementing the scattered-light time-history diagnostic on the NIF (p. 46). The diagnostic will be deployed at 15 locations around the NIF target chamber for the purpose of measuring scattered light associated with stimulated Brillouin scattering, stimulated Raman scattering, and two-plasmon decay.
- C. Dorrer *et al.* develop a novel two-wavelength phase-matching technique for measuring the deuteration level of partially deuterated KPD crystals (p. 49). Precise knowledge of the deuteration level is required for modeling and optimizing of optical parametric amplifiers.
- I. A. Begishev *et al.* achieve high-efficiency fifth-harmonic generation in large-aperture ADP crystals cooled to 200 K in a two-chamber cryostat (p. 52).
- K. R. P. Kafka *et al.* report on laser-induced-damage testing of silica and hafnia monolayers. A pump-probe configuration is used to show the presence of two different time scales for defect initiation in silica (p. 57).
- J. Puth et al. summarize operations of the Omega Laser Facility during the first quarter of FY21 (p. 60).
- G. Pien *et al.* implement the remotePI protocol to allow for continued OMEGA 60 and OMEGA EP shot operations while complying with COVID-19 restrictions (p. 62). Both facilities were able to achieve pre-COVID levels of effectiveness with reduced on-site staffing and without requiring principal investigators to be on site.

Russell K. Follett Editor