28th Annual Anomalous Absorption Conference

The Alantic Oakes
Bar Harbor, Maine
14–19 June 1998

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The Atlantic Oakes
Bar Harbor, Maine

PROGRAM

Sunday, 14 June 1998, 7:30 PM

REGISTRATION *7:30–9:00 PM* *Conference Registration and Reception*

Monday, 15 June 1998, 8:30 AM

Morning Sessions:

ORAL SESSION I *8:30–10:15 (15 Minutes Each)* *W. Seka (Chair)*

8:30 Introduction and Welcome
R. L. McCrory and D. Bradley

8:45 MO1 A Comparative Study of Laser Reflectivity Versus *f* Number in Long-Scale Hohlraum Plasmas
Juan C. Fernández, James A. Cobble, David S. Montgomery. and Mark D. Wilke

9:00 MO2 Saturated Stimulated Raman Scattering from Laser Hot Spots and Implications for Modified Electron Velocity Distributions
Don DuBois, David Russell, and Harvey A. Rose

9:15 MO3 The Scaling of SRS with Electron Temperature in Large Scale Plasmas
R. K. Kirkwood, S. H. Glenzer, B. J. MacGowan, K. G. Estabrook, R. L. Berger, E. A. Williams, J. D. Moody, and C. Decker

9:30 MO4 Effect of Laser Beam Speckle Statistics on the SBS Reflectivity: Aspects of Spatial and Temporal Smoothing Techniques
S. Hüller, Ph. Mounaix, J. Myatt, D. Pesme, L. Divol, and V. T. Tikhonchuk

9:45 MO5 Forward and Backward Stimulated Brillouin Scattering of Crossed Laser Beams
C. J. McKinstrie and E. A. Startsev

10:00 MO6 Far-Field Imaging of Stimulated Brillouin Backscatter and Stimulated Raman Backscatter from Nova Targets
Mark D. Wilke, Donald F. DuBois, Juan C. Fernández, David S. Montgomery, Harvey A. Rose, Hoanh X. Vu, Bernhard H. Wilde, Robert K. Kirkwood, and John D. Moody

10:15 Coffee Break

ORAL SESSION II *10:45–12:15 (15 Minutes Each)* *D. Montgomery (Chair)*

10:45 MO7 High-Convergence Indirect-Drive Implosions on OMEGA: Design and Simulations
P. Amendt, R. E. Turner, O. Landen, S. G. Glendinning, D. Kalantar, M. Cable, C. Decker, L. J. Suter, R. Wallace, B. A. Hammel, J. D. Kilkenny, D. Bradley, F. Marshall, R. Keck, V. Glebov, W. Seka, J. Schnittman, J. Soures, R. Craxton, R. McCrory, T. Murphy, N. Delamater, J. Wallace, C. Barnes, and A. Hauer

11:00	MO8	Hohlraum Energetics with Smoothed Laser Beams *S. H· Glenzer, L. J. Suter, R. E. Turner, B. J. MacGowan, K. G. Estabrook, M. A. Blain, S. N. Dixit, B. A. Hammel, R. L. Kauffman, R. K. Kirkwood, O. L. Landen, M. C. Monteil, J. D. Moody, T. J. Orzechowski, D. M. Pennington, G. F. Stone, and T. L. Weiland*
11:15	MO9	Analysis of Tetrahedral Hohlraum Experiments at OMEGA *J. M. Wallace, K. A. Klare, G. R. Magelssen, E. L. Lindman, T. J. Murphy, N. D. Delamater, S. M. Pollaine, R. E. Turner, R. S. Craxton, and J. D. Schnittman*
11:30	MO10	Radiation Drive Symmetry in OMEGA Tetrahedral Hohlraums *J. D. Schnittman, R. S. Craxton, N. D. Delamater, K. A. Klare, T. J. Murphy, J. M. Wallace, E. L. Lindman, G. R. Magelssen, J. A. Oertel, and S. M. Pollaine*
11:45	MO11	Advances in Diagnosing, Understanding and Controlling X-Radiation Flux in ICF Hohlraums *L. J. Suter, E. Dattalo, N. Dague, C. D. Decker, S. Glenzer, J. P. Jadaud, O. L. Landen, M-C Monteil, R. E. Turner, M. A. Blain, S. Dixit, S. G. Glendinning, B. A. Hammel, J. Knauer, B. J. MacGowan, F. J. Marshall, T. J. Murphy, D. Bradley, W. Seka, J. M. Soures, J. Wallace*
12:00	MO12	Surrogate Target Designs for Emulating NIF Plasma Conditions *C. Decker, D. E. Hinkel, R. L. Berger, E. A. Williams, L. S. Suter, B. J. MacGowan, R. K. Kirkwood, and L. Lours*
12:15		Lunch
6:00		Dinner

-------------------------- Evening Session, Monday, 15 June 1998, 7:30 PM ------------------ (J. Dahlburg, Chair)

REVIEW TALK: (45 minutes each)

7:30	MR1	Hydrodynamic Instabilities in Indirect-Drive ICF *Steven W. Haan*

MIXED POSTER SESSION

MP1	Active Localization: Convective to Absolute Instability Transitions in Active Media with Refractive Index Fluctuations *B. B. Afeyan and R. P. Ratowsky*
MP2	Chirped Pulse Reflectivity in Laser Driven Shock Experiments *A. Benuzzi, T. Hall, F. Scianitti, M. Koenig, D. DiSanto, D. Batani, and B. Faral*
MP3	A 3D Model for the Growth, Saturation, and Competition of Filamentation, SBS and SRS *R. L. Berger, B. I. Cohen, A. B. Langdon, B. J. MacGowan, J. Rothenberg, C. W. Still, E. A. Williams, E. Lefebvre, and D. F. DuBois*
MP4	Trident Experiments Seeking Indirectly-Driven Ion Waves *James J. Carroll III, R. Paul Drake, T. B. Smith, N· A. Maslov, H. Reisig, David S. Montgomery, Robert G. Watt, John S. DeGroot, and Edward A. Williams*
MP5	Stimulated Brillouin Scattering that Shouldn't be There *R. Paul Drake, James J. Carroll III, T. B. Smith, N· A. Maslov, H. Reisig, David S. Montgomery, Robert G. Watt, and John S. DeGroot*

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Hosted by the University of Rochester
Laboratory for Laser Energetics

Conference Cochairs:	David Bradley
	Jacques Delettrez
Conference Coordinator:	Jean Steve

MP6 A Variational Principle Approach to the Study of Short-Pulse Laser-Plasma Instabilities
B. J. Duda and W. B. Mori

MP7 Angular Dependence of Stimulated Brillouin Scattering
R. E. Giacone and C. J. McKinstrie

MP8 Argon K-Shell Stark Broadening Analysis of a Sequence of Neon-Doped Microballoon Implosions
Donald Haynes, Mark Gunderson, Gwyneth Junkel, Charles Hooper, David Bradley, Jacques Delettrez, and Sean Regan

MP9 A Work-in-Progress: The 350 eV NIF Target
D. E. Hinkel and S. W. Haan

MP10 Stimulated Brillouin Backscatter in the Presence of Transverse Plasma Flow
D. E. Hinkel, R. L. Berger, E. A. Williams, A. B. Langdon, B. F. Lasinski, C. H. Still

MP11 Spectroscopic Diagnostics of Tungsten-Doped CH Plasmas
M. Klapisch, D. Colombant, and T. Lehecka

MP12 Exact Green Function for a Class of Parametric Instabilities
A. V. Kanaev and C. J. McKinstrie

MP13 Beam Crossing Studies in the Context of the Indirect Drive Concept of ICF
P. Loiseau, M. Casanova, S. Hüller, and P. Mora

MP14 Strong Self-Focusing and Localization of Stimulated Brillouin Scattering in Quasi-Steady Laser Plasma
V. Malka, F. Amiranoff, S. D. Baton, A. Modena, M. Salvati, C. Coulaud, N. Renard, C. Rousseaux, S. Hüller, and C. Stenz

MP15 Analysis of Imploded Capsule Images from Spherical Hohlraums with Tetrahedral Illumination
T. J. Murphy, J. M. Wallace, K. A. Klare, J. A. Oertel, N. D. Delamater, A. A. Hauer, R. S. Craxton, J. Schnittman, F. J. Marshall, D. Bradley, and S. M. Pollaine

MP15a Symmetry Measurements of Tetrahedral Hohlraums
S. M. Pollaine, S. G. Glendinning, P. Amendt, N. D. Delamater, K. A. Klare, T. J. Murphy, J. A. Oertel, J. M. Wallace, D. Bradley, S. Craxton, and J. Schnittman

MP16 3/2 Harmonic Emission From Two-Plasmon Decay in Inhomogeneous Plasmas
D. A. Russell, D. F. DuBois, and Harvey A. Rose

MP17 Comparison Between Particle-in-Cell and Quasilinear-Zakharov Simulations for ICF Parameter Regimes
K. Y. Sanbonmatsu, H. X. Vu, D. F. DuBois, and B. Bezzerides

MP18 A High-Gain Pellet Design for Direct-Drive Laser Fusion
Andrew J. Schmitt, Steve Bodner, and John Gardner

MP19 Some New Analytical Results on Self-Focusing of Short-Pulse Lasers in Plasmas
K-C. Tzeng and W. B. Mori

MP20 ASPEN: A Fully Kinetic, Two Dimensional Particle-in-Cell Code for Simulating Parametric Instabilities in Laser-Produced Plasma
H. X. Vu, B. Bezzerides, and D. F. DuBois

MP21 Hybrid Code Development for LPI Applications
E. J. Valeo

MP22 On the Ionization State Dependence of Plasma Viscosity
K. G. Whitney

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Tuesday, 16 June 1998, 8:30 AM

Morning Sessions:

ORAL SESSION I — 8:30–10:15 (15 Minutes Each) — C. Barnes (Chair)

8:30 TuO1 Study of the Effects of 2D Perturbations on the Ignition Criteria Using Self-Similar Profiles

R. Kishony, D. Shvarts, and I. Kelson

8:45 TuO2 Simulations of OMEGA Spherical Implosions

R. P. J. Town, R. P. Bahukutumbi, J. A. Delettrez, R. Epstein, F. J. Marshall, P. W. McKenty, D. D. Meyerhofer, and S. Skupsky

9:00 TuO3 Simulations in One Dimension of the Effect of Fuel-Pusher Mix in Laser-Driven Implosions on Core Temperatures and Densities Determined from Core Emission Spectroscopy

R. Epstein, J. A. Delettrez, R. P. J. Town, D. K. Bradley, D. Haynes, C. F. Hooper, and C. P. Verdon

9:15 TuO4 Scaling Relations and Shock Velocities in Supernova Remnant Simulation Experiments

R. Paul Drake, James J. Carroll III, Tim Smith, N. A. Maslov, S. Gail Glendinning, Kent Estabrook, Bruce A. Remington, Russell Wallace, and Richard McCray

9:30 TuO5 Laser-Driven Rayleigh-Taylor Instability Experiments for Materials with Strength

S. V. Weber, J. D. Colvin, D. H. Kalantar, K. O. Mikaelian, B. A. Remington, L. G. Wiley, B. Failor, A. Hauer, J. O. Kane, M. A. Meyers, and J. S. Wark

9:45 TuO6 Perturbation Transfer in an Accelerated Shell: Feed-In and Feed-Out

R. Betti, V. Lobatchev, and R. L. McCrory

10:00 TuO7 Mass Perturbation Growth in Ablatively Driven Weakly Non-Uniform Foam Laser Targets

Alexander L. Velikovich, Giora Hazak, Jill P. Dahlburg, Robert H. Lehmberg, and John H. Gardner

10:15 Coffee Break

ORAL SESSION II — 10:45–12:15 (15 Minutes Each) — R. Kirkwood (Chair)

10:45 TuO8 Flow Induced Bending of Laser Beams Smoothed by FM-SSD

E. A. Williams, D. E. Hinkel, R. L. Berger, A. B. Langdon, and C. H. Still

11:00 TuO9 Interpretation of Long-Scale-Length Plasma Characterization Experiments on OMEGA

R. S. Craxton, D. D. Meyerhofer, and W. Seka

11:15 TuO10 Electron Temperature and Density Measurements of Long-Scale-Length, Laser Produced Plasmas on OMEGA

S. P. Regan, D. K. Bradley, A. V. Chirokikh, R. S. Craxton, D. D. Meyerhofer, W. Seka, R. P. J. Town, B. Yaakobi, R. P. Drake, and J. J. Carroll III

11:30 TuO11 Stimulated Brillouin Backscattering in NIF Direct-Drive Scale Plasmas

W. Seka, D. K. Bradley, A. V. Chirokikh, R. S. Craxton, S. Regan, D. D. Meyerhofer, R. W. Short, A. Simon, B. Yaakobi, J. J. Carroll III, and R. P. Drake

11:45 TuO12 Laser-Plasma Interaction Experiments in a Single Hot Spot

D. S. Montgomery, H. A. Rose, R. P. Johnson, J. A. Cobble, J. C. Fernández, and E. L. Lindman

12:00 TuO13 Measurements of Density Fluctuations and Beam-Spray in a Large Scalelength Nova Gasbag Plasma Using Near Forward Laser Scattering

J. D. Moody, B. J. MacGowan, B. B. Afeyan, S. H. Glenzer, R. K. Kirkwood, W. L. Kruer, S. M. Pollaine, A. J. Schmitt, and E. A. Williams

12:15 Lunch

6:00 Dinner

------------------------- Evening Session, Tuesday, 16 June 1998, 7:30 PM --------------------- (J. Meyer, Chair)

REVIEW TALK: (45 minutes each)

7:30 TuR1 Parametric Instabilities and Thompson Scattering: A Perfect Marriage

Hector A. Baldis

MIXED POSTER SESSION

TuP1 Linear and Nonlinear Pinhole Plasma Physics in NIF Spatial Filters

B. B. Afeyan, J. P. Matte, R. P. J. Town, C. D. Boley, K. G. Estabrook, and R. P. Ratowsky

TuP2 EOS Data Experiments for CH Foams Using Smoothed Laser Beams

A. Benuzzi, M. Koenig, B. Faral, F. Philippe, D. Batani, F. Scianitti, L. Müller, F. Torsiello, T. Hall, N. Grandjouan, and W. Nazarov

TuP3 Dynamics of Axial Plasma Flows in Laser-Induced Hot Spots

B. Bezzerides, R. A. Kopp, and H. X. Vu

TuP4 Diagnosis of the Propagation of a Blast Wave Generated by the Petawatt Laser System

K. S. Budil, B. A. Remington, D. M. Gold, K. Estabrook, R. Lerche, P. M. Bell, J. A. Koch, J. Kane, D. Pennington, C. Brown, M. Key, and M. D. Perry

TuP5 Growth of Stimulated Raman Scattering in the Presence of Short-Wavelength Density Modulations

M. Curtet, G. Bonnaud, and G. Laval

TuP6 Fast Electron Generation by Intense Laser Pulses in Underdense Plasma

Eric Esarey, B. Hafizi, R. Hubbard, A. Ting, and W. Leemans

TuP7 LASNEX Simulations of 4 Astrophysical Phenomena: Supernova Shocks, Plasma Jet, Micrometeor Cratering and Blast Wave on the Nova and PetaWatt Lasers

Kent Estabrook, R. Paul Drake, Bruce Remington, Gail Glendinning, Kim Budil, James Stone, Dave Farley, Michael Wood-Vasey, D. H. Munro, L. J. Suter, J. H. Harte, G. B. Zimmerman, D. S. Bailey, Jave Kane, Russell Wallace, R. A. London, A. M. Rubenchik, Dmitri Ryutov, S. V. Weber, S. P. Hatchett, and R. McCray

TuP8 Study of the Saturation of Stimulated Raman Scattering by Secondary Decays

C. G. R. Geddes, R. K. Kirkwood, S. H. Glenzer, K. G. Estabrook, C. Joshi, and K. B. Wharton

TuP9 Experimental Study of Visible and Near UV Harmonic Generation From the Interaction of an Ultra Short Pulse Laser with a Solid Target

C. T. Hansen and P. E. Young

TuP10 High Pressure Solid State Hydrodynamic Instability Growth Experiments on the Nova Laser

D. H. Kalantar, E. A. Chandler, J. D. Colvin, B. A. Remington, S. V. Weber, L. G. Wiley, J. S. Wark, A. A. Hauer, B. Failor, and M. A. Meyers

TuP11 The Significance of Stimulated Brillouin and Raman Backscatter from the Target as a Source for Optics Damage in NIF/LMJ Lasers

B. Langdon, B. MacGowan, R. Berger, S. Dixit, M. Feit, J. Hendrix, D. Hinkel, R. Kirkwood, K. Manes, J. Miller, J. Moody, J. Murray, T. Parham, A. Rubenchik, C. Still, C. Stolz, E. Williams, and B. Van Wonterghem

TuP12 Theory of the Linear Feed-Out in Planar Geometry

V. Lobatchev, R. Betti, and R. L. McCrory

TuP13 Effects of Induced Spatial Incoherence on Stimulated Brillouin Backscattering

Ph. Mounaix, S. Hüller, L. Divol, and V. T. Tikhonchuk

TuP14 Comparison of Different Optical Smoothing Methods for Reduction of Filamentation of Laser Beams in ICF Context

G. Riazuelo, E. Lefebvre, and G. Bonnaud

TuP15 Investigation of Fusion Neutrons Produced in the Focus of a 200-mJ Ti:Sapphire Laser

G. Pretzler, A. Saemann, K. Eidmann, C. Gahn, D. Habs, J. Meyer-ter-Vehn, A. Pukhov, D. Rudolph, T. Schätz, U. Schramm, P. Thirolf, G. D. Tsakiris, and K. J. Witte

TuP16 Wave Kinetic Formulation of Neutrino and Photon Driven Forward Stimulated Scattering Instabilities

L. O. Silva, R. Bingham, J. M. Dawson, W. B. Mori, J. T. Mendonça, and P. K. Shukla

TuP17 Large-Scale Filamentation Simulations with YF3D

C. H. Still, R. L. Berger, A. B. Langdon, E. A. Williams, and S. H. Langer

TuP18 Fluorescence Based Visualization/Diagnosis of Laser Driven Radiation-Hydrodynamics Experiments

L. J. Suter, O. L. Landen, and D. H. Cohen

TuP19 Theory of Nonlocal Transport for Low-Z Plasmas

V. Yu. Bychenkov, V. N. Novikov, and V. T. Tikhonchuk

TuP20 Study of X-Ray Image Characteristics in Short Pulse High Intensity Laser Plasma Interaction

M. Tsukamoto, S. P. Hatchett, M. D. Feit, A. M. Rubenchik, S. C. Wilks, D. M. Pennington, C. G. Brown, J. D. Moody, J. A. Koch, P. M. Bell, M. D. Perry, and M. H. Key

TuP21 Formation of Initial Perturbation of Rayleigh-Taylor Instability in Laser Irradiated Targets

H. Azechi, K. Shigemori, M. Nakai, N. Miyanaga, and R. Ishizaki

TuP22 Studies of High Intensity Laser Interactions with Long Scale-Length Plasmas

R. Kodama, K. A. Tanaka, K. Takahashi, Y. Sentoku, N. Izumi, H. Habara, K. Okada, M. Iwata, T. Matsushita, M. Allen, T. Iwatani, T. Kanabe, H. Fujita, Y. Kitagawa, Y. Kato, T. Yamanaka, and K. Mima

Wednesday, 17 June 1998, 8:30 AM

Morning Sessions:

ORAL SESSION I ***8:30–10:15 (15 Minutes Each)*** ***S. Wilks (Chair)***

8:30	WO1	Suppression of Electron Blowout and Relativistic Self-Focusing by the Occurrence of Raman Scattering and Plasma Heating *K-C. Tzeng and W. B. Mori*
8:45	WO2	Study of the Energy Transport in Solid Targets Irradiated by Intense Ultrashort Laser Pulses Using X-Ray Spectroscopy *A. Saemann, K. Eidmann, E. Andersson, E. Förster, and R. C. Mancini*
9:00	WO3	Observation of Neutron Spectrum From Deuterated Plastic Irradiated by Sub-Picosecond Ultra-Intense Laser *N. Izumi, K. Miyoshi, K. Takahashi, H. Habara, R. Kodama, K. A. Tanaka, S. Sentoku, and K. Mima*
9:15	WO4	High Energy Electrons Produced During Ultrafast Laser-Solid Interaction *T. Schlegel, S. Bastiani, L. Gremillet, C. Quoix, P. Audebert, J-P. Geindre, J. C. Gauthier, A. Heron, J. C. Adam, G. Laval, E. Lefebvre, C. Toupin, and G. Bonnaud*
9:30	WO5	Magnetic Field Generation in Short Pulse Laser-Plasma Interactions *M. G. Haines*
9:45	WO6	Magnetic Field Collimation of Fast Electrons in Solid Targets *J. R. Davies, A. R. Bell, M. Tatarakis, and A. E. Dangor*
10:00	WO7	Long Wavelength Hosing *K-C. Tzeng, R. G. Hemker, B. J. Duda, and W. B. Mori*
10:15		Coffee Break

ORAL SESSION II ***10:45–12:30 (15 Minutes Each)*** ***T. Johnston (Chair)***

10:45	WO8	Laser Penetration in Overdense Plasmas at Relativistic Intensities *J. Fuchs, J. C. Adam, F. Amiranoff, S. D. Baton, N. Blanchot, P. Gallant, L. Gremillet, A. Héron, J. C. Kieffer, G. Laval, G. Malka, J. L. Miquel, P. Mora, H. Pépin, and C. Rousseaux*
11:00	WO9	Ionization Induced Scattering of Short Intense Laser Pulses *Thomas M. Antonsen Jr. and Zhigang Bian*
11:15	WO10	NIF Power Balance *Ogden S. Jones, D. Ralph Speck, John T. Hunt, Steven W. Haan, and Larry J. Suter*
11:30	WO11	A Parallelized Laser Ray Tracer for ICF3D *T. B. Kaiser, J. L. Milovich, M. K. Prasad, and A. I. Shestakov*
11:45	WO12	Scattering of X-Rays by Dense Plasmas *D. Riley, N. C. Woolsey, D. McSherry, and E. Nardi*
12:00	WO13	The OMEGA Charged-Particle Spectrometer: Initial Results *R. D. Petrasso, D. Hicks, C. K. Li, F. H. Seguin, J. Soures, J. Knauer, J. Law, T. Phillips, C. Sangster, M. Cable, T. Bernat, and J. Schnittman*
12:15		Business Meeting
12:30		Lunch

------------------------- Evening Session, Wednesday, 17 June 1998 ---------------------------(D. Bradley, Chair)

6:30	Banquet Reception
7:30	Banquet Dinner
8:15	Acadia's Rocky Shore Museum *M. Furnari*

Thursday, 18 June 1998, 8:30 AM

Morning Sessions:

ORAL SESSION I ***8:30–10:15 (15 Minutes Each)*** ***R. McCrory (Chair)***

8:30 ThO1 Late-Time Evolution of Broad-Bandwidth, Laser-Imposed Nonuniformities in Accelerated Foils

D. D. Meyerhofer, T. R. Boehly, D. K. Bradley, T. Collins, J. A. Delettrez, V. N. Goncharov, J. P. Knauer, R. P. J. Town, V. A. Smalyuk, D. Oron, Y. Azebro, and D. Shvarts

8:45 ThO2 Initial Studies of Hydrodynamics of Cylindrical Implosions Using Direct Drive on the OMEGA Laser

Cris W. Barnes, David L. Tubbs, Peter L. Gobby, Nelson M. Hoffman, Ken A. Klare, John A. Oertel, Robert G. Watt, Thomas R. Boehly, David Bradley, and James P. Knauer

9:00 ThO3 Mix Experiments on the 60 Beam OMEGA Laser System Using Smoothing by Spectral Dispersion (SSD)

J. Delettrez, D. K. Bradley, S. Regan, T. Boehly, J. P. Knauer, and V. Smalyuk

9:15 ThO4 Convergent Rayleigh-Taylor Experiments on the Nova Laser

C. Cherfils, D. Galmiche, A. Richard, S. G. Glendinning, S. Haan, B. A. Remington, R. Wallace, and V. N. Goncharov

9:30 ThO5 Computations of Gold Coated Plastic Laser Accelerated Targets

Jill P. Dahlburg, Stephen P. Obenschain, Tom Lehecka, Denis Colombant, Andrew J. Schmitt, John H. Gardner, Lee Phillips, and Marcel Klapisch

9:45 ThO6 Recent Studies in the Nonlinear Evolution of Rayleigh-Taylor and Richtmyer-Meshkov Instability

D. Shvarts, D. Oron, U. Alon, and Y. Yedvab

10:00 ThO7 Equation of State Measurements of Hydrogen Isotopes up to 3 Mbar

G. W. Collins, P. Celliers, L. B. Da Silva, R. Cauble, D. Gold, M. Foord, K. S. Budil, R. Stewart, N. C. Holmes, M. Ross, B. A. Hammel, J. D. Kilkenny, R. J. Wallace, and A. Ng

10:15 Coffee Break

ORAL SESSION II ***10:45–12:15 (15 Minutes Each)*** ***R. P. Drake (Chair)***

10:45 ThO8 New Beam Smoothing Experiments at the Nova Laser

B. J. MacGowan, R. L. Berger, B. I. Cohen, C. D. Decker, S. Dixit, C. Geddes, S. H. Glenzer, D. E. Hinkel, R. K. Kirkwood, A. B Langdon, B. F. Lasinski, E. Lefebvre, L. Lours, J. D. Moody, J. E. Rothenberg, C. Rousseaux, L. J. Suter, C. H. Still, and E. A. Williams

11:00 ThO9 Generation of Large Levels of Ion Acoustic Waves by Combined Spatial and Temporal Beam Smoothing

J. F. Myatt, S. Hüller, Ph. Mounaix, D. Pesme, V. T. Tikhonchuk, and W. Rozmus

11:15 ThO10 Observation of Resonant Energy Transfer Between Identical-Frequency Laser Beams

K. B. Wharton, R. K. Kirkwood, S. H. Glenzer, K. G. Estabrook, B. B. Afeyan, B. I. Cohen, J. D. Moody, and C. Joshi

11:30 ThO11 Pushing the Limits: Strongly-Driven Laser Plasma Coupling

W. L. Kruer,E. M. Campbell, C. D. Decker, S. C. Wilks, J. Moody, T. Orzechowski, L. Powers, L. J. Suter, B. B. Afeyan, and N. Dague

11:45 ThO12 Return-Current Electrons and Their Generation of Electron Plasma Waves

A. Simon

12:00 ThO13 The Two Plasmon Decay Instability with Overlapping Structured Laser Beams in Direct Drive Laser Fusion Targets

B. B. Afeyan, A. J. Schmitt, S. Bodner, R. Lehmberg, and J. Rothenberg

12:15 Lunch

6:00 Dinner

------------------------- Evening Session, Thursday, 18 June 1998, 7:30 PM --------------------(R. Short, Chair)

REVIEW TALK: (45 minutes each)

7:30 ThR1 Behavior and Implications of Time Dependent Filamentation in ICF

Andrew J. Schmitt

MIXED POSTER SESSION

ThP1 New Phase Space Techniques for Beam Propagation in Inhomogeneous, Anisotropic and Nonlinear Media

B. B. Afeyan, R. P. Ratowsky, J. Kallman, and M. Feit

ThP2 Simulations of Tungsten, Tungsten-Coated and Tungsten-Doped Targets at Low KrF Laser Intensities

D. Colombant, T. Lehecka, J. Seely, M. Klapisch, A. Schmitt, and S. Obenschain

ThP3 Observations of Time-Dependent Symmetry in Tetrahedral Hohlraums at Omega Using the Reemission Technique

N. D. Delamater, G. R. Magelssen, K. Klare, J. Oertel, J. Wallace, P. Gobby, R. S. Craxton, J. D. Schnittman, W. Seka, D. A. Bradley, J. J. MacFarlane, and S. M. Pollaine

ThP4 Mesoscale Analysis of Nonlinear SRS in Large Systems

Don DuBois and David Russell

ThP5 LLNL Nova Laser Irradiated Gold Disk Experiments Diagnosed with Thomson Scattering Compared to LASNEX Simulations

Kent Estabrook, Siegfried Glenzer, Christina A. Back, W. Rozmus, George B. Zimmerman, John S. DeGroot, R. W. Lee, Brian Wilson, Brian MacGowan, Hans Griem, Judith A. Harte, and David S. Bailey

ThP6 Shinethrough of Various Barrier-Layer Materials

Y. Fisher, T. R. Boehly, D. K. Bradley, D. R. Harding, D. D. Meyerhofer, and M. D. Wittman

ThP7 Modeling Laser Driven Radiography

S. P. Hatchett, S. C. Wilks, and M. D. Perry

ThP8 X-Ray Emission Spectroscopy of Deeply Buried Tracer Layers as a Deep-Heating Diagnostic for Fast Ignitor Experiments

J. A. Koch, S. P. Hatchett, R. W. Lee, M. H. Key, O. L. Landen, C. Brown, B. A. Hammel, J. D. Moody, D. Pennington, M. D. Perry, M. Tabak, and S. Wilks

ThP9 Ultra High Intensity Inverse Bremsstrahlung

I. Yu. Kostyukov and J.-M. Rax

ThP10 Modeling ICF Capsule Line Emission in 3 Dimensions

Steven H. Langer, Howard A. Scott, Michael M. Marinak, and Otto L. Landen

ThP11 Numerical Simulation of X-Ray Laser Signal Build-Up Using a Maxwell-Bloch Description

O. Larroche, D. Ros, A. Klisnick, A. Sureau, C. Möller, D. Benredjem, and H. Guennou

ThP12 PIC Simulations of Hole-Boring for Fast-Ignitor Applications

Barbara F. Lasinski, A. Bruce Langdon, Max Tabak, and Michael H. Key

ThP13 Simulation of Rayleigh-Taylor Growth in Experiments with Radiatively Driven Thin Planar Foils

R. J. Mason, D. E. Hollowell, and G. T. Schappert

ThP14 Polarization Smoothing for ICF with MegaJoule Class Lasers

Joshua E. Rothenberg

ThP15 Transmission Through Highly Overdense Plasma Slabs with a Subpicosecond Relativistic Laser Pulse

C. Rousseaux, J. C. Adam, F. Amiranoff, S. D. Baton, N. Blanchot, J. Fuchs, L. Gremillet, A. Héron, J. C. Kieffer, G. Laval, J. L. Miquel, P. Mora, and H. Pépin

ThP16 2D Simulations of Multimode Perturbations in Ablatively Driven Foils

D. Oron, Y. Srebro, D. Ofer, and D. Shvarts

ThP17 Simulations of SSD Smoothing of Laser Nonuniformity in Directly Driven Foils

D. Ofer, D. Oron, Y. Srebro, D. Shvarts, S. Skupsky, J. Delettrez, and C. P. Verdon

ThP18 The "Return" of the Electron Beam

A. Simon

ThP19 Nonlinear Evolution of the 3-D Broad-Bandwidth Spectrum of Imprinting in Planar Targets Accelerated by UV Light

V. A. Smalyuk, T. R. Boehly, D. K. Bradley, J. P. Knauer, D. D. Meyerhofer, D. Oron, Y. Azebro, and D. Shvarts

ThP20 Reduction of Early-Time Perturbation Growth in Ablatively Driven Planar Laser Targets Using Tailored Density Profiles

Nathan Metzler, Alexander L. Velikovich, and John H. Gardner

ThP21 Propagation of Fast Electrons into Thick Solid Targets in High Intensity Laser-Solid Interactions

M. Tatarakis, J. R. Davies, K. Krushelnik, A. R. Bell, E. L. Clark, A. Machacck, R. Marjoribanks, P. A. Norreys, M. Santala, J. S. Wark, I. Watts, M. Zepf, M. G. Haines, and A. E. Dangor

Friday, 19 June 1998, 8:30 AM

Morning Sessions:

ORAL SESSION I 8:30–10:45 (15 Minutes Each) *D. Meyerhofer (Chair)*

8:30 FO1 Interaction of an Ultraintense Laser Pulse with an Overdense Plasma: Relativistic Electron, Ion, and Neutron Production

C. Toupin, E. Lefebvre, G. Bonnaud, and C. Lebourg

8:45 FO2 Oblique Stimulated Raman Scattering of a Short Laser Pulse in a Plasma Channel

E. J. Turano and C. J. McKinstrie

9:00 FO3 Filamentation of a 500 fs Laser Beam at 1053 nm Wavelength over Long Distances in Air

T. W. Johnston, B. LaFontaine, F. Vidal, Z. Jiang, C. Y. Chien, J.-C. Kieffer, H. P. Mercure, and H. Pépin

9:15 FO4 Channel Formation and High Energy Ions Generation in Interaction of Short Intense Laser Beam with an Underdense Plasma

G. S. Sarkisov, V. Yu. Bychenkov, V. N. Novikov, V. T. Tikhonchuk, A. Maksimchuk, S. Y. Chen, R. Wagner, G. Mourou, and D. Umstadter

9:30 FO5 Absorption of Ultra-Short, Ultra-Intense Laser Light by Solids and Over-Dense Plasmas

S. C. Wilks, W. L. Kruer, T. Cowan, S. P. Hatchett, M. Key, J. A. Koch, A. B. Langdon, M. D. Perry, M. Tabak, and K. B. Wharton

9:45 FO6 Stimulated Brillouin Scattering in High-Intensity, Self-Focused Filaments: The Effects of Sound Wave Diffraction and Plasma Flow

R. W. Short

Coffee Available—No official break is scheduled today

10:00 FO7 Accurate Formulas for the Landau Damping Rates of Electrostatic Waves

E. A. Startsev, C. J. McKinstrie, and R. E. Giacone

10:15 FO8 Nonlinear Theory of Power Transfer Between Multiple Crossed Laser Beams in a Flowing Plasma

Harvey A. Rose and Sandip Ghosal

10:30 FO9 Theoretical Analysis of Thomson Scattering from Laser Produced Plasmas

W. Rozmus, S. Glenzer, K. Estabrook, H. A. Baldis, B. MacGowan, and P. E. Young

10:45 FO10 Two Plasmon Decay and Filamentation in a CO_2 Laser Produced Plasma

Jochen Meyer

ORAL SESSION I

W. Seka, Chair

Monday, 15 June 1998

M01

A comparative study of laser reflectivity versus f number in long-scâle hohlraum plasmas

Juan C. Fernández, James A. Cobble
David S. Montgomery and Mark D. Wilke
Los Alamos National Laboratory, Los Alamos, NM 87545 USA

April 13, 1998

The reflectivity of a 351 nm, $f/4.3$ laser beam from stimulated Raman scattering (SRS) in a long-scale Nova hohlraum plasma is observed to depend on the damping rate of ion-acoustic waves [Fernández *et al.*, Phys. Plasmas **4** (1997) 1849]. As SRS is unrelated to such waves, this is taken as evidence of nonlinear SRS saturation due to secondary decay processes of the SRS daughter plasma wave, such as the Langmuir Decay Instability (LDI) [DuBois and Goldman, PRL **14** (1965) 544]. The decay of plasma waves via LDI is unrelated to the laser f number, which correspondingly would suggest an SRS saturation level independent of f number. However, dependence on the f number could appear indirectly through other processes, such as self focusing. In contrast, the convective SRS gain depends on f number, which is expected to affect directly the critical onset intensity for SRS, just like it does for stimulated Brillouin scattering (SBS) [Rose *et al.*, Phys. Plasmas **72** (1994) 2883]. We present recent SRS reflectivity measurements on the Nova toroidal hohlraum plasmas of an $f/8$ beam to compare to the $f/4.3$ measurements and to test these models. Different gas-fill species are used to vary the acoustic damping. The SBS reflectivity measurements are also presented and compared.

This work is supported by DOE Contract W-7405-ENG-36.

M02

SATURATED STIMULATED RAMAN SCATTERING FROM LASER HOT SPOTS AND IMPLICATIONS FOR MODIFIED ELECTRON VELOCITY DISTRIBUTIONS*

Don DuBois[a], David Russell[b] and Harvey A. Rose[a]
[a]Los Alamos National Laboratory
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ABSTRACT

Results from 1D and 2D reduced model simulations[1] of the nonlinear saturation state of SRS from single random-phase-plate-processed laser hot spots will be summarized. The model includes the saturation processes of pump depletion, Langmuir decay instability (LDI) cascades, Langmuir collapse, and ponderomotive density profile modification. The dependencies of the SRS reflectivity on electron temperature, electron density, ion acoustic damping, and hot spot intensity have been studied. The Landau damping of the SRS Langmuir waves, as determined by a Maxwellian electron velocity distribution function, is so large that the simulations cannot account for the LDI-saturated SRS observed[2,3,4] at low densities and high temperatures in NIF emulation experiments. The ponderomotive pressure and the Ohmic dissipation of the SRS Langmuir waves in the saturated state are often found to significantly exceed those of the pump wave. The Langmuir wave Ohmic dissipation may significantly enhance the "flat topped" modification of the electron velocity distribution over that predicted from the pump alone[5]. Using the simulation Langmuir wave electric field Fourier spectra it is found that in the range of resonant velocities the quasilinear diffussion term can exceed the Langdon[6] Ohmic heating term even when the latter is enhanced by LW dissipation. The competition of Ohmic and quasilinear modifications of the Langmuir wave Landau damping may be important in the development and saturation of SRS.

1. David Russell, D.F. DuBois, and Harvey A. Rose (submitted to POP 1998)
2 J.C. Fernandez et al Phys. Rev. Lett.77, 2702, (1996)
3. R.K. Kirkwood et al Phys. Rev. Lett.77, 2706, (1996)
4. D.S. Montgomery et al Phys. Plasmas 3, 1728 (1996)
5. B.B. Afeyan et al , Phys. Rev. Lett.,2322, (1998)
6. A.B. Langdon, Phys. Rev. Lett.44, 575, (1980)

* For oral presentation at the 28th Anomalous Absorption Conference, Bar Harbor, Maine, June 14-19, 1998

Research supported by the USDOE

Everything has an effect on everything else.

Twenty-Eighth Annual Anomalous Absorption Conference
Bar Harbor, Maine
June 14, 1998

The Scaling of SRS with Electron Temperature in Large Scale Plasmas

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R. L. Berger, E. A. Williams, J. D. Moody, and C. Decker,
Lawrence Livermore National Laboratory

We have performed a series of experiments using the Nova laser facility which investigate the dependence of Stimulated Raman Scattering (SRS) on both the plasma electron temperature, and the electron-ion collision rate in ignition relevant plasmas. Earlier work has shown that in these plasmas, SRS reflectivity scales with the damping rate of the ion acoustic wave [1], and that the response of the SRS generated Langmuir wave is non-linear [2], suggesting that SRS is determined by non-linear coupling of the Langmuir wave to other waves. The scaling of SRS with electron temperature in the presence of non-linear, multi-wave, coupling is likely to be much different than predicted by a linear-three wave model. We find, using a pre-heated 'gas bag' target filled with C_5H_{12} and a Xe impurity, that we can vary the electron temperature and the electron-ion collision rate ($<Z^2>/<Z>$) separately, by varying either the percent Xe while the heater power and electron temperature are constant, or by varying the impurity fraction. This allows the collisional damping rate of the Langmuir and light waves to be varied separately from the Landau damping rates of the Langmuir and ion acoustic waves, and the effect of each on the reflectivity to be determined. Results at $I = 2$ to 4×10^{15} W/cm^2 show a moderate decrease in the SRS reflectivity when the electron temperature is decreased and a similar decrease when the impurity fraction and $<Z^2>/<Z>$ are increased. This suggests that electron-ion collisions are the dominant process determining the scaling of saturated SRS with electron temperature.

[1] R. K. Kirkwood et. al. Phys. Rev. Lett. 77, 2706 (1996). and J. C. Fernandez et. al. Phys. Rev. Lett. 77, 2702 (1996).
[2] R. K. Kirkwood et. al. submitted to Phys. Rev. Lett.

*Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48.

We request an oral session on Wednesday evening or later. Later in the week is preferable.

M04

Effect of laser beam speckle statistics on the SBS reflectivity: aspects of spatial and temporal smoothing techniques

S. Hüller, Ph. Mounaix, J. Myatt, and D. Pesme,
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L. Divol,
CEA Bruyères-le-Châtel, France,
V.T. Tikhonchuk,
P. N. Lebedev Physics Institute, Moscow, Russia

We investigate the reflectivity due to stimulated Brillouin scattering from ensembles of laser speckles for different speckle statistics. For the case of merely spatial smoothing, in particular RPP and "polarization smoothing", one observes that besides the speckle statistics, the self-focusing of intense speckle leads, under certain conditions, to a higher threshold intensity for SBS and to a saturation of SBS due to density depletion.
Spatio-temporal smoothing is investigated for the case of "Induced spatial incoherence" (ISI) under the aspect of (a) spatio-temporal speckle statistics and (b) transient growth of SBS and ion fluctuations.
Our results are based on analytic and numerical modeling, and on two-dimensional (2D) and three-dimensional (3D) numerical simulations taking into account both SBS and self-focusing/filamentation processes.

Forward and Backward Stimulated Brillouin Scattering of Crossed Laser Beams

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Parametric instabilities driven by crossed laser beams can occur in direct-drive and indirect-drive fusion experiments. In linear analyses of such instabilities,[1–3] the scattering process at a particular angle is independent of the scattering processes at different angles; when nonlinear effects become important, however, the scattering processes at different angles become coupled. As a simple paradigm of nonlinear competition, we analyze the forward and backward SBS of crossed laser beams (and show that the near-forward and near-backward SBS of isolated laser beams are governed by the same equations). Backward SBS dominates the early stages of the combined instability because its transient time is shorter than that of forward SBS. When forward SBS develops the backward scattered intensity decreases, but the total scattered intensity increases because forward SBS extracts energy from the pump beam more efficiently than backward SBS.

Prefer oral session.

This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

1. D. F. DuBois, B. Bezzerides, and H. A. Rose, Phys. Fluids B **4**, 241 (1992).
2. C. J. McKinstrie and M. V. Goldman, J. Opt. Soc. Am. B **9**, 1778 (1992).
3. V. V. Eliseev *et al.*, Phys. Plasmas **3**, 2215 (1996).

M06

Far-field Imaging of Stimulated Brillouin Backscatter and Stimulated Raman Backscatter from Nova Targets

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Robert K. Kirkwood, John D. Moody
Lawrence Livermore National Laboratory, Livermore, CA 94550

We have an initial set of far-field images of stimulated Brillouin scatter (SBS) and stimulated Raman scatter (SRS) in the backward direction from Nova targets using the Full Aperture Backscatter Station Imager (FABSI). The new diagnostic is comparable to a large microscope capable of far field imaging through a random phase plate (RPP) using the Nova lens as an objective while correcting for both the phase changes from the RPP and the chromatic aberrations generated by the single-element final focusing lens. The far field imager can take four 100 ps time-resolved images per shot gated at four independent times. Any combination of four backscatter images filtered for stimulated Brillouin scattering (SBS) and/or stimulated Ramon scattering (SRS) can be obtained on a single shot. The resolution is better than 25 um. The initial images were obtained from gas filled large torroidal hohlraums, scale-1 hohlraums and gas bag targets. We have observed the spatial distribution of the backscatter at the target in the far-field including the image evolution with time. We have also attempted to determine the location of the source of SRS backscatter in the longitudinal direction by focusing the imager at different locations in the plasma along the direction of the interaction beam. The features of the images and the trends in the data will be discussed.

This work is supported by DOE Contract W-7405-ENG-36.

ORAL SESSION II

D. Montgomery, Chair

Monday, 15 June 1998

High-convergence indirect-drive implosions on OMEGA: design and simulations

P. Amendt, R.E. Turner, O. Landen, S.G. Glendinning, D. Kalantar, M. Cable, C. Decker, L.J. Suter, R. Wallace, B.A. Hammel, J.D. Kilkenny

University of California, Lawrence Livermore National Laboratory

D. Bradley, F. Marshall, R. Keck, V. Glebev, W. Seka, J. Schnittman, J. Soures, R. Craxton, R. McCrory

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ABSTRACT

Use of the multi-cone geometry of OMEGA in indirect-drive experiments enables the experimental testing of some NIF-relevant issues. For example, a similarity of the laser cone angles on OMEGA (22°, 42.4°, 58.9°) with those of the NIF (23°, 30°, 45.5°, 50°) allows testing of some aspects of hohlraum flux symmetry. In our previous indirect-drive campaigns on OMEGA, a considerable level of P4 flux asymmety on target was generally found. Our current focus is to use the shallow cone on OMEGA to significantly reduce this level of P4 flux asymmetry. Such reduced time-integrated flux asymmetry is important for achieving high-convergence implosions. Another crucial component of capsule performance is achieving reduced time-dependent flux asymmetry excursions. On the NIF, implementation of beam-phasing is envisioned as the means of controlling P2 flux excursions to less than 5%. However, OMEGA is not configured for beam-phasing and alternative methods are needed. Beam-staggering on OMEGA has been successfully demonstrated in the past, but it is not sufficiently flexible for the high-contrast pulseshapes required for high-convergence implosion studies. Instead, we have found via analysis and simulation studies a symmetry effect intrinsic to a multi-cone geometry which can be utilized to reduce time-varying flux asymmetry. High convergence implosion designs are presented which take advantage of the improved flux symmetry. Using PS26 (5-to-1 contrast pulseshape) we show that imploding capsules with convergences of nearly 20 are predicted on OMEGA with 2-D simulated yields within 85% of clean (1-D) yields.

Work performed under the auspices of the U.S. Department of Energy under Contract W-7405-ENG-48.

• Prefer oral presentation (adjacent to R. Turner's talk)

α

M08

Hohlraum Energetics with smoothed Laser Beams

S. H. Glenzer, L. J. Suter, R. E. Turner, B. J. MacGowan, K. G. Estabrook, M.~A.~Blain*, S. N. Dixit, B. A. Hammel, R. L. Kauffman, R. K. Kirkwood, O. L. Landen, M.-C. Monteil*, J.~D.~Moody, T. J. Orzechowski, D.~M.~Pennington, G.~F.~Stone, and T.~L.~Weiland

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We have used beam smoothing on Nova's ten laser beams to produce scale-1 hohlraums of high radiation temperatures. These experiments where performed wtih gas-filled and with empty hohlraums heated with shaped laser pulses which are used for capsule implosions at Nova. We observe low laser scattering losses due to laser-plasma instabilities and improved coupling of the laser energy into the hohlraum when applying laser beam smoothing techniques. Under best smoothing conditions, i.e. kinoform phase plates and smoothing by spectral dispersion with a bandwidth of 0.22nm, we find that for pulse shape no.26 (PS26) with intensities up to 4 x 10^{15} W cm^{-2} more than 93% of laser light was absorbed during the 1-ns long high power part of the laser (which had a total duration of 2.4 ns). For pulse shape no.22 (PS22) with intensities up to 2 x 10^{15} W cm^{-2} more than 95% of the laser light was absorbed during that time. Experimental data indicate that scattering losses are small because filamentation and gain for stimulated Raman and stimulated Brillouin scattering are reduced for smoothed laser beams. We clearly observe higher radiation temperatures, exceeding 230 eV, with increasing absorbed laser energy. The radiation temperatures of both the gas-filled and the empty hohlraums are seen to compare well with each other and they agree with detailed radiation-hydrodynamic simulations using LASNEX with a standard deviation of 4 eV. In addition, the radiation temperatures follow the Marshak scaling for ablative heat waves for a laser conversion efficiency of 90%.

This work was performed under the auspices of the U.S. Department of Energy under contract No. W-7405-ENG-48.

PREFER ORAL SESSION

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Analysis of Tetrahedral Hohlraum Experiments at OMEGA

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S.M. Pollaine and R.E. Turner
Lawrence Livermore National Laboratory, Livermore, CA 94551, USA
R.S. Craxton and J.D. Schnittman
Laboratory for Laser Energetics, Rochester, NY 14623-1299, USA

The Tetrahedral hohlraum, spherical in shape with four laser entrance holes located at the vertices of a tetrahedron, has been proposed as a means for attaining highly uniform capsule irradiation with laser-driven, indirect-drive inertial confinement fusion. This is a necessary requirement for symmetric capsule implosions and the ultimate achievement of ignition in the laboratory. Recent hohlraum experiments on the 60-Beam OMEGA laser system at the Laboratory of Laser Energetics, University of Rochester, have been quite successful in producing highly symmetric capsule implosions at modest convergence. An analysis of the experiments performed to date will be presented, including comparison of theoretical modeling and experimental data. Topics to be discussed include Hohlraum Energetics, Beam Pointing, Radiation Drive Symmetry, Capsule Performance, and Computational Methods.

* Work supported by U.S. Department of Energy.

oral session preferred

M010

Radiation Drive Symmetry in OMEGA Tetrahedral Hohlraums

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S. M. Pollaine
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Recent experiments on OMEGA have shown that spherical hohlraums with tetrahedral symmetry are a viable alternative to cylindrical hohlraums for indirect-drive ICF experiments. The tetrahedral geometry allows all 60 OMEGA beams to be used, as opposed to the maximum of 40 beams for cylindrical hohlraums. This enables us to reach higher temperatures and a more uniform drive. It has also been shown that the radiation drive symmetry can be easily tuned by varying the size of the laser entrance holes (LEH's), analogous to tuning the length of a cylindrical hohlraum.

The 3-D code *BUTTERCUP* has been extended to include a 1-D radiation diffusion model at each point on the hohlraum wall. The code has been used to calculate the locations of beam spots on the hohlraum wall, the absorption and x-ray conversion of laser energy, the radiation transport, and the drive symmetry on the imploding capsule. The calculations predict hohlraum temperatures and albedos as a function of time that are in close agreement with experimental measurements and 1-D and 2-D LASNEX simulations. A simple model gives the time-dependent geometric coupling of radiation between the wall and the imploding capsule.

Using a variety of techniques, including foam balls, re-emission targets, and thin-shelled symmetry capsules, the drive symmetry was measured for hohlraums with LEH radii of 350 and 500 μm. For both targets, the drive symmetry was dominated by a Y32 spherical harmonic moment, characteristic of the tetrahedral geometry. *BUTTERCUP* predicts drive asymmetries of ~1% rms for the 350-μm LEH's and 2.5% rms for 500-μm LEH's, which are supported by experimental results.

Prefer oral presentation.

ACKNOWLEDGMENT

This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

M011

Advances in diagnosing, understanding and controlling x-radiation flux in ICF hohlraums

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Recent changes in the way in which we perform hohlraum drive experiments, together with a broader variety of experiments have significantly advanced our ability to diagnose, understand and control the x-radiation flux (or drive) inside an ICF hohlraum. The changes, which have occurred over the past two years as part of a multi-laboratory, French-American collaboration, include:

1- The advent of the Omega laser at the University of Rochester, which allows us to do indirect drive experiments on a 20TW class facility other than Nova and with a more flexible geometry.

2- First on Omega, then on Nova, we now monitor drive by measuring radiation flux through the hohlraum laser entrance hole (LEH), complementing the traditional measurement made through a hole in the side of the hohlraum.

3- We have developed a relatively simple photo-conducting diamond (PCD) based radiation flux diagnostic that allows us much greater flexibility in fielding a drive diagnostic.

4- Nova has been upgraded to perform experiments with smoothing via KPP (Kinoform Phase Plates) and, optionally, SSD (Smoothing by Spectral Dispersion) on all ten beams.

5- We have developed alternative drive diagnostics which we are using to complement and validate the LEH drive measurements. These techniques include thin, gold burn-thru foils and backlit, imploding spheres in the center of the hohlraum.

What we have found in these two years is that similar experiments performed on both Omega and Nova produce similar drive measurements, demonstrating that experiments on these large facilities are reproducible. Measurements of drive through the LEH, which simulations show to be more directly representative of the capsule flux than through the traditional side hole, provide evidence for a relatively detailed, quantitative understanding of the time dependent radiation flux inside the hohlraum during the entire course of the laser pulse. This differs from previous, scaling type measurements thru the traditional side hole which showed a quantitative understanding of the overall energetics, but suggested faults in modeling the detailed drive history. We now believe the earlier discrepancies to be an artifact of the diagnostic line of sight. Experiments using 10 smoothed beams to irradiate ignition style, gas-filled hohlraums show acceptable (<10%) backscatter losses and radiation temperatures as high as 230eV, in good accord with simulations. Similar experiments with reduced scale hohlraums which fill to quite high plasma densities ($>>0.1n_c$) also show low backscattering. Their radiation temperatures, which we measure to approach 270eV, also appear in good accord with modeling. Finally, observations of the trajectory of backlit, foam balls provides corroboration of LEH measurements of drive during the foot of an experiment driven by a shaped laser pulse. Gold burn-thru foils, although not yet conclusive, suggest that the drive at the peak of the pulse is also consistent with the LEH measurements. Currently, we are working to measure peak drive in highly filled hohlraums via backlit, imploding spheres.

* Work performed under the auspices of the United States Department of Energy, by the Lawrence Livermore National Laboratory under Contract No. W-7405-ENG-48, by Los Alamos National Laboratory under Contract No. W-7405-ENG-36 and by CEA.

M012

28th Annual Anomalous Absorption Conference
14-19 June 1998

Surrogate Target Designs for emulating NIF plasma conditions

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Over the last several years, many experiments have been performed on Nova to evaluate backscattering instabilities for plasma conditions similar to those expected for the NIF point design hohlraum. The point design is a 300 eV radiation temperature hohlraum that will contain a low-Z plasma at about 10% critical density for 0.351 mm light.

Recently, alternatives to the point design have been considered in order to give more flexibility in choosing the eventual target design. For example, integrated designs for higher temperature (350 eV) and higher density hohlraums have been performed as well as designs for lower temperature (250eV) and lower density hohlraums.

We examine the relevant plasma conditions ,i.e., most unstable, for both the 250eV and 350eV designs. Designs for surrogate targets such as gasbags or gas filled hohlraums that will emulate the plasma conditions expected for these NIF Targets will be presented.

REVIEW TALK

J. Dahlburg, Chair

Monday, 15 June 1998

Hydrodynamic Instabilities in Indirect-Drive ICF

S. W. Haan

Invited review talk for June 1998 Anomalous Absorption Conference, Bar Harbor, Maine

Hydrodynamic instabilities in indirect-drive ICF*

Steven W. Haan
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This talk reviews the status and progress made in the area of hydrodynamic instabilities in ICF capsules. Current interest centers on the stability of ignition targets for the proposed National Ignition Facility. Instability growth on these targets has been modeled in various ways,using both 2D and 3D simulations. The inferred requirements on surface roughness and laser uniformity are tight but not impossible. Much of the physics underlying these projections can be substantiated with existing experimental results, especially for indirectly driven CH-ablator targets. Direct drive is also becoming more substantiated with ongoing experimental campaigns. Some uncertainty remains in projections for NIF, because of uncertainty both in the modeling and in the input to the modeling. For indirect drive, the possible use of attractive new ablator materials (beryllium and polyimide) has raised new issues. Quantitive modeling of growth using these materials is being tested in current and future experiments. Short-wavelength structures and material anisotropy issues in beryllium may require the development of new modeling capability.

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MIXED POSTER SESSION

Monday, 15 June 1998

28

Twenty–Eighth Annual Anomalous Absorption Conference
Bar Harbor, Maine
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Active Localization: Convective to Absolute Instability Transitions in Active Media with Refractive Index Fluctuations

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The usual notions of wave propagation and scattering which rely on adiabaticity, slow variation, or WKB like concepts fail to capture a fascinating phenomenon, which in optics gives rise to so called "White Paint Lasers.[1]" These are entirely due to non-paraxial effects and are a manifestation of long range order and self-organization amid turbulence. Here we explore the theory of this general phenomenon which we refer to as "active localization" (to contrast it with the well known Anderson or passive localization[2]). Using SOFTSTEP simulations, we study the temporal evolution of an electromagnetic field in one and two dimensions in plasmas with fluctuating density profiles. Saturable gain, saturable nonlinear self-focusing and periodic density profiles are also included. Connection with and extensions of the Nicholson model[3] for parametric instabilities in inhomogeneous and turbulent plasmas are given. The results of the direct numerical (SOFTSTEP) simulations are interpreted using semi-analytic statistical models and asymptotic techniques.

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PREFER POSTER SESSION

CHIRPED PULSE REFLECTIVITY IN LASER DRIVEN SHOCK EXPERIMENTS

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We performed an experiment based on using two pulses delivered by the 100 TW LULI laser. The first one is an uncompressed (FWHM Å 600 ps) chirped main pulse generating a shock wave in a CH-Al target coated into 2 mm fused quartz. The target rear side emissivity was recorded by a visible streak camera in order to check the shock uniformity. The second one is a partially compressed (FWHM Å 100 ps) chirped probe pulse[1] which irradiates the rear face of the target (the quartz side). We measured *on each shot* the reflected probe phase change as function of time using the frequency domain interferometry technique[2]. Such measurement allowed us to deduce the interface Al-quartz displacement velocity which gives informations on preheating effects and on fluid velocity.

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A 3D model for the growth, saturation, and competition of filamentation, SBS and SRS

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abstract

In experiments at LLNL and elsewhere on a variety of targets, an anticorrelation between levels of SRS and SBS backscattered light has been noted. The onset of saturated levels occurs for mean intensities well below those required for growth from thermal noise because of the presence of hotspots in the laser beam. SSD and other beam smoothing techniques have been shown to reduce the SBS and SRS reflectivity, although with only modest effect in some experiments with high gain. Using the 3D wave propagation code, F3D {R. L. Berger et al., Phys. Fluids B 5, 2243 (1993)}, with nonlinear models for the backscattered SBS and SRS {for SRS saturation models, see D. F. DuBois submitted to PoP 1998}, we have computed the reflectivity as a function of intensity, electron density, electron temperature, and electron-ion temperature ratio. By assumption, we are limited to near backscatter or near forward scatter. However, we find that the scattered light amplitude is strongly peaked in angle for which our approximations are valid. The saturation of SBS and SRS is associated with strong modulation of the density, the ion temperature, the flow velocity.

MP4

28th ANNUAL ANOMALOUS ABSORPTION CONFERENCE

Trident Experiments Seeking Indirectly-Driven Ion Waves

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The saturation of driven ion waves in the dense plasmas created in laser fusion experiments is not well-understood. Recent theoretical progress suggests that the non-resonant decay instability may be the key mechanism. Related simulations see this process and evidence of induced scattering.[1] Induced scattering appeared to explain ion wave saturation in microwave-driven plasmas.[2] Either of these mechanisms will be more effective in three dimensions than in two, and thus is a candidate for the observed ion wave saturation. In induced scattering, an ion acoustic wave is scattered by a direct, kinetic interaction with the thermal ions in the plasma. This leads principally to scattering in angle as opposed to a change in frequency or wavenumber. We report here results of an experiment that could have detected induced scattering if it were essential to ion wave saturation in short-wavelength-laser plasmas.

The experiment used 3 laser beams: a preform beam, a pump beam, and a probe beam. The wavelength of all the beams is 527 nm. The preform beam (175 J, 1.3 ns square pulse), using a line-focus RPP, creates a plasma from a CH target (6.5 μm thick, 1 mm wide). Ion acoustic waves, with $k=2k_0$, where k_0 is the wavenumber of the 527 nm beam, are driven at a density of ~0.06 critical via backscatter SBS using the pump beam (<25 J, 200 ps Gaussian pulse centered 1.6 ns from the start of the preform beam). The probe beam (<15 J, 1.3 ns square pulse beginning at 1.0 ns after the start of the preform beam), whose intensity is below the SBS threshold, is arranged at an angle of 30° from the pump beam. Backscatter signals from the probe beam are injected into the Michigan Optical Spectroscopy System to measure the frequency spectrum of the ion acoustic waves at $\pm 2k_0$. The detection of strong $2k_0$ ion acoustic waves at an angle 30° from the original SBS-pump-beam direction would be attributed to induced scattering. We detected enhanced but weak acoustic waves, which might also be due to mode coupling. We will show data and analysis.

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Work supported by the U.S. DOE and the University of Michigan

1. B.I. Cohen, B.F. Lasinski, A.B. Langdon and E.A. Williams, *Phys. Plasmas* 4, 956 (1997).
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Poster Preferred

28th ANNUAL ANOMALOUS ABSORPTION CONFERENCE

Stimulated Brillouin Scattering that shouldn't be there

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There has been notable progress in accounting for the onset of stimulated Brillouin scattering (SBS) in recent years, once random phase plates have given known statistics to the laser intensity distribution and the theory has accounted for this.[1] The onset has been as anticipated in both uniform plasmas[2,3,4] and plasmas with velocity gradients.[5,6] We report here an experiment that confounds these implications, perhaps initiated by non-resonant coupling between two laser beams.

The experimental setup is as reported in the previous abstract by Carroll *et al.* A 1.3 ns preform beam uses a line focus to generate a plasma. At 1.0 ns, a probe beam begins to irradiate this plasma at an angle of 60° to the target normal. The probe beam is masked so as to miss the initial target and to irradiate primarily the underdense plasma in front of it. If the intensity of this probe beam exceeds ~ 5×10^{12} W/cm^2, which is roughly the collisional damping threshold for SBS, then significant backscattered, redshifted signal is seen which endures for the entire probe pulse. As we shall show, the gain for SBS during this period is too small to account for these results. We speculate that nonresonant coupling to the preform beam initiates the scattering, which then perhaps surprisingly manages to sustain itself even after the preform beam ends.

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Work supported by the U.S. DOE and the Univeristy of Michigan

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Poster Preferred; following Carroll, *et al.*

MP6

1998 Anomalous Absorption Conference
Bar Harbor, Maine
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Abstract

A Variational Principle Approach to the Study of Short-Pulse Laser-Plasma Instabilities

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The attractiveness of variational principle approaches for obtaining good approximations to complicated problems is well established. Motivated by this fact, we have developed a variational principle approach to the study of short-pulse laser-plasma instabilities. We start with an action of the form

$$S = \int d\vec{x}_\perp d\psi d\tau \, L$$

where the Euler-Lagrange equations of L, the Lagrangian density, give the well established coupled equations of short-pulse interactions

$$2i\frac{\omega_o}{c}\frac{\partial}{\partial\tau}a - \nabla_\perp^2 = \phi a$$

$$\frac{\partial^2}{\partial\psi^2}\phi + \omega_p^2\phi = \frac{|a|^2}{2}$$

We substitute appropriate trial functions for a and ϕ into S and carry out the $\int d\vec{x}_\perp$ integration. The Euler-Lagrange equations of the reduced Lagrangian density provide coupled equations for the spot sizes, amplitude, phase, radius of curvature and centroids for both a and ϕ. The linearized versions of these equations provide the growth rates for the usual envelope self-modulation and hosing instabilities. We are in the process of considering more complicated coupled instabilities and the effects of dispersion.

This work is supported by DOE grant numbers DE-FG03-92-ER40727 and DE-FG03-98DP00211, LLNL contract W-7405-ENG-48, and NSF grants DMS-9722121 and DA21777-2.

Angular Dependence of Stimulated Brillouin Scattering

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We continue the study of the angular dependence of SBS[1–5] in both the transient and steady-state regimes. The 2-D envelope equations governing SBS are solved numerically for a wide interaction region, which corresponds to a loosely focused laser beam, and a narrow interaction region, which corresponds to a tightly focused beam or a filament. The equations, solved for laser and plasma parameters that correspond to strong and weak ion-acoustic damping, illustrate the relative importance of damping and convection in saturating the instability. Good agreement is found between the predictions of idealized analytical formulas[3,4] and the numerical results.

Prefer poster session.

This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

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MP8

Abstract Submitted
for the 28th Annual Anomalous Absorption Conference

Argon K-shell Stark broadening analysis of a sequence of neon-doped microballoon implosions DONALD HAYNES, MARK GUNDERSON, GWYNETH JUNKEL, CHARLES HOOPER, University of Florida, DAVID BRADLEY, JACQUES DELETTREZ, SEAN REGAN, LLE, University of Rochester — Analysis of time-resolved x-ray spectroscopic data from microballoon implosions conducted using the Omega laser is presented. In a sequence of six implosions, CH microballoons of approximately 440 micron inner radius and 19 micron thickness were filled with a 20 Atm mixture of deuterium, argon, and neon. The argon atomic concentration was fixed at 1%, while that of neon varied from 0% to 20%. The differing amounts of neon led to different time histories of electron density and temperature during the implosions. LILAC simulations illustrating the effects of increasing Ne concentration are presented. Time-resolved Ar K-shell spectra were recorded, and are compared with analytically-calculated, temperature- and density-sensitive spectra. The analytical spectrum combines Stark broadened line profiles using NLTE relative intensities, including the effects of ion dynamics, opacity broadening, and plasma-induced line shifts. This work was supported in part by the U.S. Department of Energy National Laser Users Facility Program, DE-FG03-97SF21270.

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- [ ] Prefer Oral Session
- [X] Prefer Poster Session

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28th Anomalous Absorption Conference

A Work-in-Progress: The 350 eV NIF Target *

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Currently, design is underway on the 350 eV hohlraum target for National Ignition Facility (NIF) applications. To achieve a radiation temperature of 350 eV with NIF, where maximum power is roughly 500 TW and maximum energy is 1.8 MJ, the hohlraum and thus the capsule is scaled to roughly 65 % that of the 300 eV point design. The capsule consists of DT gas of radius 490 μm, overlaid with a solid DT layer 90 μm thick. The beryllium ablator is 130 μm thick, and the inner 70 μm of the ablator is doped with copper at the 1 % level. One-dimensional simulations demonstrate a yield of $\sim$ 6 MJ when this capsule is radiated with a four-tier drive that peaks at 350 eV.

In two-dimensional simulations, the capsule is placed in a hohlraum 6.1 mm in length and 3.56 mm in diameter, where the laser entrance holes are 2.67 mm in diameter. The laser pulse is 13.3 ns long, reaching a peak power of 500 TW at about 11.5 ns. In this smaller, hotter NIF hohlraum, both the motion of the gold hohlraum wall and the beryllium ablator inhibits the power deposition of the inner beam in the hohlraum wall. Thus, to hold back the wall as well as the ablator, the H-He gas fill inside the hohlraum has been increased from 0.87 mg/cc (300 eV design) to $\sim$ 2.5 mg/cc. Symmetry and tuning results will be presented.

Along the outer NIF beam cone, the electron temperature T_e is fairly constant at about 9 keV; along the inner beam cone, $T_e \sim 9$ keV over 1.5 mm before it begins to drop off. The ion temperature $T_i \sim 2$ keV over most of the beam along the outer and inner cones. The electron plasma density n_e is above 0.1 of critical density for most of the beam path, from the laser entrance hole to the hohlraum wall. Initial assessments of the level of backscatter for both Raman and Brillouin as well as for beam deflection will be presented.

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MP10

28th Anomalous Absorption Conference

Stimulated Brillouin Backscatter in the Presence of Transverse Plasma Flow *

D. E. Hinkel, R. L. Berger, E. A. Williams, A. B. Langdon,
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Experiments recently performed on the Nova laser at Lawrence Livermore National Laboratory (R. K. Kirkwood *et al.*) in gas-filled, Scale 1 hohlraums show that laser light scattered back to the lens is shifted away from the center of the lens. It has been proposed by H. A. Rose (LANL) that plasma flow transverse to the laser beam, which has been shown to deflect the incident beam in the direction of the flow, also shifts the backscattered light in the anti-flow direction. To understand the underlying physics of the problem, proof-of-principle fluid simulations using F3D [R. L. Berger *et al.*, Phys. Fluids B **5**, 2243 (1993)] /NH3 [C. H. Still *et al.*, ICF Quarterly Report **6**, 138 (1996).] have been performed. F3D/NH3 is a three-dimensional, nonlinear hydrodynamics and heat transport code coupled to light wave propagation. A variety of simulations have been performed in both two dimensions and in three dimensions for a Gaussian laser beam, a spatially smoothed laser beam and a spatially/temporally smoothed laser beam.

These simulations show that plasma flow transverse to the laser beam reduces the reflectivity of the backscattered light, an effect attributed to convective damping, i.e., the acoustic wave that scatters the incident light is swept out of the laser beam by the plasma flow. This results in a higher effective damping rate on the ion acoustic wave.

Transverse flow can displace the backscattered light as well as reduce reflectivity levels. In the absence of transverse flow, the peak in both the forward and backscattered light remains aligned at its initial location. However, when there is transverse plasma flow, the forward light is deflected. Simulations show that the backscatter gain is dominated by the section of the simulation region where the incident light is deflected. This occurs because the backscatter gain was weighted to this region by an increasing plasma density profile.

When the plasma has an axial flow with a scalelength $L_u \leq L$, the backscatter in the deflected portion of the incident beam is non-resonant with the undeflected portion of the incident beam. This mechanism serves also to deflect the backscattered light. When the backscattered light that amplifies along the deflected incident light path is non-resonant with the plasma where the incident light is undeflected, there will be backscattered light reflected at angles similar to those of the incident light, only in the anti-flow direction rather than the flow direction.

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Spectroscopic diagnostics of tungsten-doped CH plasmas

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Spectra of CH with different concentrations of W dopant and laser intensities (2.5-10 $\times 10^{12}$ W/cm^2) were obtained at NRL with the Nike Laser. They were recorded in the 100-500eV range with an XUV grating spectrometer. The hydrodynamic simulations are performed with the 1D code FAST1D[1, 2] where non LTE effects are introduced by Busquet's model[3, 4]. They are then post-processed with TRANSPEC[5], a time dependent collisional radiative code with radiation coupling. The necessary atomic data are obtained from the HULLAC code[6]. The post processing and diagnostics were performed on carbon lines and the results are compared with the experimental data.
This work was supported by USDOE under contract with the Naval Research Laboratory, Laser Plasma Branch.

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MP12

Exact Green Function for a Class of Parametric Instabilities

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In recent years, several authors studied the spatiotemporal evolution of parametric instabilities such as SBS and SRS. These studies were based on the Green function, or impulse response, which characterizes the instabilility evolution. In the weak-coupling regime, exact and time-asymptotic formulas for the Green function are known;[1–4] in the strong-coupling regime, however, only the time-asymptotic formula is known.[4,5] We determine the exact formula for arbitrary values of the coupling strength and interaction time. This exact formula is required to model the instability growth accurately during the transition between the strong- and weak-coupling regimes.

Prefer poster session.

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Withdrawn Paper: Please Note: MP12 has been withdrawn from Monday's Poster Session.

28th Annual Anomalous Absorption Conference - June 14–19, 1998 - Bar Harbor, Maine

Beam crossing studies in the context of the indirect drive concept of ICF

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Targets designed for the indirect drive approach of ICF are centimeter-size cavities with 2 or 3 mm wide entrance holes where many laser beams overlap. The physics of energy transfer between crossing beams has been addressed in several recent papers [1-4]. The transfer proves to be very sensitive to external parameters, particularly when the beam crossing takes place in a flowing plasma. In the vicinity of the laser entrance holes (LEH) three materials coexist : the gas inside the cavity, the plastic window stopping the gas flow, and the gold-coated wall cavity. Thus, adequate models are needed to understand the beam crossing physics in as wide a range of plasma conditions as possible.

In order to characterize the plasma near the LEH, we present a study of the characteristic quantities obtained from the 2D hydro code FCI2. In further steps we investigate the laser plasma interaction in the vicinity of LEH. First, we consider the energy transfer via Bragg diffraction for 2D geometry in a homogeneous plasma for the cases of crossing laser beams with and without frequency detuning. In a further step we include parametric effects like Brillouin scattering and filamentation in our calculations. Numerical simulations are performed with the multi-dimensional wave-coupling code KOLIBRI [5]. In order to characterize the efficiency of the crossing of two smoothed laser beams, we adopt a statistical laser speckle description applying it to the energy transfer function for this process. Comparison of the models with recent experiments [4,6] will be given.

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MP14

Strong Self-Focusing and Localization of Stimulated Brillouin Scattering in Quasi-Steady Laser Plasma

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The localization of ion waves generated by SBS has been studied in an experiment with a 1.053 μm nanosecond laser pulse and a fully ionized plasma. The plasma is created by the interaction of a pre-ionizing beam with a gas jet. This produces a well-controlled, homogenous and quasi-stationary plasma at electron densities of $2\text{-}10 \times 10^{19}$ cm^{-3}. Thomson scattering imaging diagnostic is used to localize plasma waves excited by stimulated Brillouin and Raman scattering in the pre-ionized gas jet plasma. The power of the interacting laser beam is far beyond the critical power for ponderomotive self-focusing. Changing the focal position of the laser beam in an almost parabolic density profile proves to have only a weak influence on the position of the plasma waves with respect to the density profile. Increasing, however, the plasma density, moves the position of the waves towards the incoming laser beam. Theoretical considerations confirm this behavior and show that the underlying process is governed by the ratio between laser power and self-focusing critical power.

Analysis of Imploded Capsule Images from Spherical Hohlraums with Tetrahedral Illumination

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Tetrahedral hohlraums (spherical hohlraums with four laser entrance holes) have potential advantages over cylindrical hohlraums for symmetric implosion of ICF capsules.[1,2] These include the elimination of the P_2 mode in both a time-averaged and time-dependent sense.

Experiments have been performed at the OMEGA Laser Facility in which "standard" capsules have been imploded using tetrahedral hohlraums. The fuel of the capsule was doped with Argon to allow x-ray images of the imploded core to be obtained. Analysis of the shape of the image yields information on the time-integrated symmetry of the radiation drive.[3]

The analysis of images from tetrahedral hohlraums is analogous to those from cylindrical hohlraums, but with a different emphasis. The lowest order mode in an ideal tetrahedral experiment is the $Y_{3,2}$ mode. Imaging in tetrahedral hohlraums is generally done through one of the laser entrance holes so that the dominant asymmetry in the image is expected to be an m=3 mode, resulting from a two-dimensional projection of the $Y_{3,2}$ mode.

Imploded core images are analyzed in a similar manner to that used for implosions in cylindrical hohlraum. The image is filtered to remove noise on a scale shorter than the resolution of the instrument. The 50% contour of emission is determined and a Fourier analysis of that image is obtained of modes through m=12. Currently, the m=3 mode is used to characterize the magnitude of the asymmetry. The maximum (a) and minimum (b) radii of the contour calculated using the m=0 and m=3 components are given by $a=A_0+A_3$, $b=A_0-A_3$. The distortion from the m=3 mode is then defined as the ratio of these and is designated $[a/b]_3$.

This analysis procedure is being refined to include higher order modes and to take into account the phase of the modes relative to the LEH locations, especially for situations in which the m=3 mode has been reduced to low levels. Incorporation of information from off-axis imaging would add information about the three-dimensional shape of the imploded core and will help in interpretation of the data.

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[2] D. W. Phillion and S. M. Pollaine, *Phys. Plasmas* **1**, 2963 (1994).
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[X] Poster Presentation Preferred

MP16

Abstract Submitted to the
Twenty-Eighth Annual Anomalous Absorption Conference
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Bar Harbor, Maine

3/2 Harmonic Emission from Two-Plasmon Decay in Inhomogeneous Plasmas

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The two-plasmon decay instability may be the most difficult parametric instability to control with laser beam-smoothing techniques [1], and the hot electrons it makes may prove to be a limiting factor in the design of ICF targets. In this study, we focus attention on the $3/2\ \omega_0$ electromagnetic radiation emitted when incident laser light ($\omega_0 \geq 2\omega_{pe}$) scatters off the Langmuir waves (LWs) generated by the laser-driven two-plasmon decay (TPD) instability near $n_c/4$ in an inhomogeneous plasma. It has been suggested by many researchers that the electron temperature might be extracted from the power spectrum of this radiation. However, this extraction is made difficult by uncertainty concerning the origin of LWs contributing to the radiation. In particular, unstable TPD LWs cannot couple to this radiation locally, i.e., at the density where they are born. Therefore $3/2\ \omega_0$ emission must be the result of nonlinear processes, such as those responsible for saturating the instability, and/or of LW propagation in the density gradient. We include both effects in the numerical simulations presented here. Our study is based on a nonlinear model [2] successful in describing LW and $3/2\ \omega_0$ spectra measured in CO_2 laser experiments [3]. The model includes the physics of LW decay, LW -> LW' + ion acoustic wave, and of LW collapse; saturation of the instability is due to collisional dissipation enhanced by decay cascades and collisionless dissipation resulting from collapse. We present energy and power spectra of LWs and of the current density fluctuations driving 3/2 harmonic emission, as well as radiation patterns, in the saturated turbulent regime. Where possible, we separate linear features of the radiation power spectrum, due to TPD LW propagation in the density gradient, from nonlinear features due to LW decay and collapse. The background plasma has T_e = 1 keV and a gradient scale length of 200µm. It is irradiated by 1.064 µm light; we consider various intensities.

(a) Supported by U.S. DOE Grant # DE-FG03-98DP00205
(b) Supported by U.S. DOE

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[3] J. Meyer and Y. Zhu, Phys. Rev. Lett. **71**, 2915 (1993).

Poster Session

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45

Symmetry Measurements of Tetrahedral Hohlraums

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Tetrahedral hohlraums are a new form of indirect drive (Phillion and Pollaine, 1994; Schnittman and Craxton, 1996). The hohlraum is spherical instead of cylindrical, and has four laser entrance holes arranged in a tetrahedral configuration. Although the extra holes lead to greater radiation losses, tetrahedral hohlraums have advantages in providing a more symmetric x-ray drive for the capsule. These hohlraums were shot for the first time on the OMEGA laser at LLE, U. Rochester, on March 25-28 and on August 20-22, 1997. X-ray images of the capsule inside the hohlraum show an m=3 asymmetry, as would be expected from the effect of the laser entrance holes. A foam ball (Amendt, 1996) inside the hohlraum (500 μm LEH) measured the time-dependent asymmetry from a 22 KJ ps22 laser pulse, and found less than 2% asymmetry during the time of measurement.

We compare this result with our modeling of the asymmetry of tetrahedral hohlraums, which is dominated by the $Y_{3,2}$ mode.

Amendt, P. et al, Phys. Rev. Lett. 77, 3815-3818 (1996)
Phillion, D.W. and Pollaine, S.M., Phys. Plasmas 1, 2963-2975 (1994).
Schnittman, J.D. and Craxton, R.S., Phys. Plasmas 3 (10), 1-12 (1996).

Comparison between particle-in-cell and quasilinear-Zakharov simulations for ICF parameter regimes

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A detailed comparison between 1-D particle-in-cell and 1-D quasilinear-Zakharov simulations has been performed in order to determine the validity of the quasilinear-Zakharov model in parameter regimes relevant to laser-plasma experiments. The quasilinear-Zakharov model couples a modified quasilinear diffusion equation to the Zakharov equations, evolving the spatially averaged electron distribution and Langmuir wave spectrum self-consistently. Self-consistency is achieved by computing the Langmuir wave Landau damping rate from the evolving electron distribution and the quasilinear diffusion coefficient from the time-dependent Langmuir wave spectrum. The Zakharov equations are modified to take into account the changing electron temperature due to the evolving electron distribution. The Zakharov equations also include a collisional damping term determined by the particle-in-cell simulation. The quasilinear diffusion equation has an additional dissipative term due to the spontaneous emission of Langmuir waves.

We compare both the linear and nonlinear regimes of the pump driven Langmuir wave decay instability. Our pump is sufficiently weak to enable a detailed comparison of Langmuir wave spectra. To compare the linear stage of the instability, we initialize the quasilinear-Zakharov simulation with the same noise present in the particle-in-cell simulation. For this weakly driven case, the additional dissipative term in the quasilinear diffusion equation is important. Without it, the noise heats the electron distribution, increasing the Landau damping rate, with the net effect of quenching the instability.

We find remarkable agreement between the Langmuir wave spectra and approximate agreement for the average electrostatic energies. This work is a first step in incorporating the quasilinear-Zakharov model into a large scale ion particle-in-cell simulation, which would include both the stimulated Raman and Brillion scattering instabilities.

MP18

Abstract submitted for the 28th Annual Anomalous Absorption Conference

A High-Gain Pellet Design for Direct-Drive Laser Fusion

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Abstract

Energy applications of laser fusion require a target design that produces high gain The basic problem in such a design is to balance the needs for high gain (i.e., low adiabat compression of the DT fuel) with the needs for enhanced Rayleigh-Taylor (RT) instability (e.g., large ablation velocities, requiring high-adiabat ablators). We have approached this dichotomy by: (a) minimizing the fuel adiabat by applying almost shock-free laser drive to the pellet, while simultaneously (b) using a low density foam overcoat that substantially increases the adiabat (and thus the stability) of the target ablator. We will present one and two dimensional simulations of a design and address the possible Achilles heel of this approach, the classically RT unstable interface between the low density foam ablator and compressed fuel payload.

***Supported by U.S. Department of Energy**

1998 Anomalous Absorption Conference
Bar Harbor, Maine
June 14-19, 1998

Abstract

Some New Analytical Results on Self-Focusing of Short-Pulse Lasers in Plasmas

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We use the variational principle approach to derive envelope equations which describe self-focusing from both relativistic mass corrections and ponderomotive expulsion of electrons. The envelope equations are derived in both cylindrical and slab geometry, are drived for asymmetric spot sizes and are derived for the full nonlinearity (in cylindrical geomety). In addition, the dynamic modification to the pulses' dispersion relation as the beam focuses is derived. Exact equilibrium transverse profiles and dispersion relations are derived for slab geometry. These analytic profiles are obtined for arbitrary amounts of cavitation, i.e., regions of complete electron blowout. Comparisons to previous work, implications for experiments and simulations, and direction for future work are given.

This work is supported by DOE grant numbers DE-FG03-92-ER40727 and DE-FG03-98DP00211, LLNL contract W-7405-ENG-48, and NSF grants DMS-9722121 and DA21777-2.

MP20

ASPEN: A Fully Kinetic, Two Dimensional Particle-in-Cell Code for Simulating Parametric Instabilities in Laser-Produced Plasma

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In Inertial Confinement Fusion (ICF) applications, an external high-frequency monochromatic electromagnetic wave such as a laser is employed to irradiate the plasma. The external monochromatic electromagnetic wave, due to its interaction with the plasma, can undergo either high-frequency or low-frequency parametric instabilities, and decay into various combinations of daughter waves [1]. Recent experiments and Zakharov simulations indicate that in ICF plasmas of interest, high-frequency parametric instabilities can affect the growth and saturation of low-frequency parametric instabilities via nonlinear interactions.
Due to a multitude of spatial and temporal scales that exist in such plasmas and the fact that the external driving electromagnetic field is of high frequency, general-purpose explicit, implicit, and hybrid PIC algorithms are either incapable of simulating the actual physics, or computationally inefficient. In a recent works [2-4], a special-purpose hybrid PIC model was presented in which the electrons are modeled as an adiabatic fluid with an arbitrary ratio of specific heats γ, and the electromagnetic field model is based on a temporal WKB approximation. This hybrid model was implemented in three spatial dimensions on a CRAY-T3D with 512 processors, and was shown to model various low-frequency parametric instabilities as well as ion Landau damping correctly. However, this hybrid model does not include electron kinetic effects, and is therefore inadequate for situations in which high-frequency parametric instabilities, such as stimulated Raman scattering (SRS), play a significant role.

In this paper, we present ASPEN, a fully kinetic, reduced-description PIC model, implemented in two dimensions on the CRAY-T3D with 512 processors and on the Accelerated Strategic Computing Initiative (ASCI) parallel computer, appropriate for modeling both low-frequency ion-driven parametric instabilities and high-frequency electron driven parametric instabilities. It can be shown that in the limit where high-frequency parametric instabilities are not important, the model reduces to the aforementioned hybrid model [2-4]. First and foremost, the model treats electrons and ions as discrete finite-size particles, allowing linear and nonlinear kinetic effects to be modeled correct for both electrons and ions. The Poisson equation is solved to ensure that space-charge effects are included. The electromagnetic field is modeled using a WKB analysis that results in three coupled Schrödinger-like equations for: (1) the incident and SBS-scattered electromagnetic field, (2) the frequency-downshifted SRS-scattered electromagnetic field, and (3) the frequency-upshifted SRS-scattered electromagnetic field. The novel feature of this model is the method of extracting the temporal electron density WKB envelopes from the instantaneous electron density which, in turn, is obtained by interpolating from the particles onto the computational mesh.

1. W.L. KRUER, *The Physics of Laser Plasma Interactions* (Addison-Wesley, New York,1988).
2. H.X. VU, *J. Comput. Phys.* **124**, 417 (1996).
3. H.X. VU, `` A Massively Parallel Three-Dimensional Hybrid Code for Simulating Ion-Driven Parametric Instabilities," *J. Comput. Phys.*, to appear.
4. H.X. VU, `` Three-Dimensional Particle-in-Cell Simulations of Ion-Driven Parametric Instabilities," *Phys. Plasmas* **4**, 1841 (1997).

Hybrid Code Development for LPI Applications

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In many instances, the evolution of collective phenomena driven by intense (laser) radiation is critically dependent on nonlinear wave-particle interactions. A hybrid code is under development which exploits the fact that, typically, these interactions involve only a small fraction of the particles and occur in limited phase space volumes. The computationally efficient fluid moment description is augmented by splitting the computation of the closure moment into two parts. In the essential, resonant region of phase space the response is computed via PIC techniques. In the remainder, systematic approximations are employed. Initial results will be presented.

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MP22

ON THE IONIZATION STATE DEPENDENCE OF PLASMA VISCOSITY

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ABSTRACT

It is generally thought that ion viscosity dominates over electron viscosity in plasmas. Thus, since real viscosities are generally replaced by artificial viscosities in plasma hydrodynamics calculations, these artificial viscosities are generally introduced into the ion energy and momentum equations. Except for the introduction of a term involving the ion sound speed, these artificial viscosities do not have any dependence on the ionization state of the plasma even though real viscosities do. In this paper, a calculation of the ionization state dependence of the plasma viscosity will be described. It is shown that, for ionization states of six or more, electron viscosity can dominate over ion viscosity depending on the ratio of electron to ion temperatures. In moderate atomic number plasmas, therefore, the role that electron viscosity plays in a plasma's compression dynamics is complicated by the fact that these temperatures depend on the electron-ion energy equilibration times, which may depend on the compression dynamics of the plasma, which may, in turn, depend on the relative sizes of the real electron and ion viscosities. Some discussion of these issues vis-a-vis the use of artificial viscosities will be made.
Work supported by DSWA

ORAL SESSION I

C. Barnes, Chair

Tuesday, 16 June 1998

Study of the Effects of 2D Perturbations on the Ignition Criteria Using Self-Similar Profiles.

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The ignition conditions under which a thermonuclear burn wave propagates from an initial hot spot, and the characteristics of the propagating burn wave were investigated using a set of self-similar solutions [1]. Although the self-similar solutions exist only for external density profiles decreasing as $\rho_{ext} \propto r^{-1}$, they are shown to provide natural ignition criteria and critical profiles for more general density profiles. The self-similar solutions, which also exist in two dimensions, are used to investigate the effect of 2D perturbations on the ignition conditions. The perturbed ignition line corresponding to each perturbation multipularity, l, and perturbation amplitude, a, is derived. Using these 2D ignition lines, the increase in the implosion energy necessary to overcome the excess energy losses from the hot spot is obtained.

[1] R. Kishony, E. Waxman, D. Shvarts, Phys. Plasmas 4, 1385 (1997).

TU02

Simulations of OMEGA Spherical Implosions

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The OMEGA experimental campaign is aimed at the validation of high-performance, direct-drive capsule designs. These designs involve a thin, plastic support shell surrounding a thick DT ice layer that contains a residual, low-pressure DT gas. The DT ice layer acts as both an ablator and the main fuel layer. This presentation will present a brief review of the design considerations of such targets. As a bridge to these cryogenic targets, current OMEGA spherical implosions use "warm" surrogate plastic targets that involve an inner, 10-μm CD layer surrounding either a H_2 or D_2 gas. Simulations of such targets with various pulse shapes will be presented and comparisons will be made to recent experimental campaigns that involved the use of new ion-etched distributed phase plates (DPP's) and 2-D SSD.

Prefer oral session.

This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

Simulations in One Dimension of the Effect of Fuel–Pusher Mix in Laser-Driven Implosions on Core Temperatures and Densities Determined from Core Emission Spectroscopy

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The effects of fuel–pusher mix on emission spectra from cores of laser-driven implosions are studied using one-dimensional hydrodynamic simulations including the effects of mix due to hydrodynamic instability at the fuel–pusher interface. Core temperature and density are estimated by fitting a synthetic spectrum model to time-resolved spectra from recent experiments. Similar analyses performed on synthetic spectra obtained from hydrodynamic simulations using the same atomic-physics radiation-transport model demonstrate the self-consistency of this estimation method and also identifies points on the temperature and density profiles of the simulated cores as source points. The relationship between the emission-averaged temperature estimated from spectral analysis and the neutron-weighted ion temperature from neutron energy spectroscopy is considered. Also, the relationship between the effects of fuel–pusher mix on the core spectrum and on the spectrum of emission from a shell additive used to signal the occurrence of mix is examined. The effects of Rayleigh–Taylor flow are simulated in one dimension by the hydrocode *LILAC*. Mix is modeled as a diffusive transport process affecting material constituents, thermal energy, and turbulent mix-motion energy within a growing mix region whose boundaries are derived from a saturable linear multimode model of the Rayleigh–Taylor instability. The linear growth rates and the coupling between perturbations of different interfaces are calculated in terms of the one-dimensional fluid profiles. Mode evolution proceeds according to equations applicable to all phases of acceleration, and the effects of geometrically converging, compressible flow are taken into account. Spectra are simulated using a simple non-LTE screened-hydrogenic radiation-transport post-processor that makes full use of the multimaterial mix information from the one-dimensional hydrodynamic simulations.

Prefer oral session.

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TU04

28th ANNUAL ANOMALOUS ABSORPTION CONFERENCE

Scaling Relations and Shock Velocities in Supernova Remnant Simulation Experiments

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Richard McCray,
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Natural plasma systems are replete with hydrodynamic phenomena driven by supersonic, flowing plasma. One dramatic example is found in the behavior of supernova remnants, in which the expanding ejecta sweep up the surrounding matter, producing strong shocks, hydrodynamic instabilities, and emissions at many observable wavelengths. We are studying the hydrodynamic behavior of a laboratory system which is a good scaled model of such supernova remnants. In the context of laboratory hydrodynamics, this system has the unique aspect that the hydrodynamic effects are driven by a supersonic flow rather than by ablation. We are using the Nova laser to investigate such a system.[1] We produce high-Mach-number ejecta by driving a strong shock out the back of a plastic slab. These ejecta then impact a low-density foam, where the ejecta stagnate and form a reverse shock while driving a strong shock forward through the foam. We observe this hydrodynamic assembly by x-ray radiography.

In this presentation, we will discuss two aspects of this system. First, we will describe the scaling from the laboratory to a supernova remnant, showing quantitatively the sense in which these might be described as identical hydrodynamic systems. Second, we will compare the observed shock velocities and the system evolution for two different values of the density of the plastic slab.

Work supported by the US DOE and the University of Michigan.

1. R.P. Drake, et al., Ap. J. Lett., in press (1998).

Oral Presentation Preferred

TU05

Laser-Driven Rayleigh-Taylor Instability Experiments for Materials with Strength*

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Materials with strength have been accelerated with pressures of up to 3 Mbar on the Nova laser using indirect drive. Modulations of wavelength 10 µm - 50 µm were imposed at the interface between a Cu foil and a brominated polystyrene ablator. A shaped laser pulse was employed to accelerate the package in the solid state, and RT growth was measured by face-on x-ray radiography. Experimental results were in good agreement with elastic-plastic simulations. Strength can stabilize the RT instability or reduce the rate of growth in certain regimes. However, strength effects were modest for the parameters of these experiments. Larger effects are predicted at shorter wavelength, lower acceleration, and for stronger materials, in qualitative agreement with theoretical predictions[1].

Dynamic x-ray diffraction allows diagnosis of the material state at high pressure. We have observed Bragg diffraction from Si compressed along the <100> or <111> crystal axes at pressures of 160 - 500 kbar, and have measured lattice compression of up to 10%. Comparison to modeling will be shown. Diffraction with Cu samples is being attempted. This diagnostic is useful to confirm the solid state of the material and to measure shock timing, as well as to probe dynamic material response.

Future experiments are being planned for the Omega laser in a direct drive configuration. Packages have been designed with internal shielding to avoid melting of the RT sample by x-ray preheat. It may be possible to attain higher pressure and longer acceleration in this configuration.

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* Work performed under the auspices of the U. S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.

[1] Nizovtsev, P. N., and Rayevsky, V. A., *VANT. Ser. Teor. I Prikl. Fizika*, 3, 11-17 (1991), ref. in *Hydrodynamic Instability in Strong Media* Lawrence Livermore National Laboratory, Livermore, CA, UCRL-CR-126710 (1997)

TU06

Perturbation Transfer in an Accelerated Shell: Feed-In and Feed-Out

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The Rayleigh–Taylor instability in a laser-accelerated target is seeded by initial target nonuniformities, laser imprinting, and perturbations transferred between the inner and outer surfaces. If the laser-illuminated surface of the target is rippled, a rippled shock travels toward the inside surface. The ripple shock transfers the perturbation from the outside to the inside surface (feed-in). After the shock breaks out, a rarefaction wave propagates from the inside toward the ablation front (outside surface). If the inside surface is rippled, then a rippled rarefaction front would transfer the perturbation from the inside to the outside surface (feed-out). This process is of great importance to inertial confinement fusion because the inside surface is usually very rough and the transmitted perturbation seeds the ablation front RT instability. The theory of the perturbation transfer is developed using a simple compressible fluid model to describe the shell. A small perturbation is superimposed to the one-dimensional solution of the propagating shock or rarefaction wave. It is shown that a rippled rarefaction wave imprints a velocity perturbation on the laser-illuminated surface. The latter develops a ripple that initially grows linearly and then exponentially. For wavelengths larger than the shell thickness, the magnitude of the velocity perturbation depends on the rippled amplitude on the inside surface, the sound speed, and the target thickness.

Prefer oral session.

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TU07

Mass perturbation growth in ablatively driven weakly non-uniform foam laser targets

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Foam materials used in laser fusion pellet design are characterized by both small- and large-scale local density variation. We analyze the interaction of a planar ablatively driven shock wave with small density non-uniformities in the pre-shock foam during the shock transit to estimate contribution of this source of mass non-uniformity to the perturbation growth at the ablation front. Results of our theoretical analysis and numerical simulations demonstrate that a constant supply of random density perturbations through the shock front does not contribute to the perturbation growth at the accelerated interface because the plasma particles carrying the start-up vorticity that drives the instability are lost through the ablation front, and there is no preferential direction of vorticity generated at the shock front interacting with the pre-shock density modulation. This conclusion changes if the density variation is structured rather than random (examples are joints and gaps in laser targets and "thermal layer"). An interesting special case is axial density modulation that introduces no vorticity to the flow, and hence, does not destabilize the ablation front, but rather makes it rapidly oscillate, which might contribute to mitigation of the Rayleigh-Taylor instability.

Work sponsored by US DOE.

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Prefer Oral Presentation

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ORAL SESSION II

R. Kirkwood, Chair

Tuesday, 16 June 1998

Abstract submitted to the 28^{th} Anomalous Absorption Conference

FLOW INDUCED BENDING OF LASER BEAMS SMOOTHED BY FM-SSD.*

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Ghosal and Rose[1,2] have developed an analytic theory of beam bending induced by plasma flow for laser beams smoothed by RPP (random phase plate) and by SSD (smooothed by spectral dispersion). In their SSD model, the temporal bandwidth is induced by random phase modulation. On Nova, Omega, and planned for NIF, the temporal bandwidth is implemented by frequency modulating the laser. Combined with the dispersion, the resulting laser beam has an instantaneous frequency that varies sinusoidally across the lens (i.e. in k-space at the focus).

We compute the beam bending coefficients for this situation. The resulting bending is not statistically stationary, but depends on the phase of the SSD modulation. Forward Brillouin Scattering between the different frequency components of the beam causes a periodic bending that adds to the time-averaged component arising from the plasma flow.

We show the results of this model as a function of plasma flow velocity and damping rate, and of the SSD smoothing parameters. We compare our analytic results with those obtained by direct simulation with our laser-plasma interaction code F3D.

* Work performed under the auspices of the United States Department of Energy by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48.

1. S. Ghosal and H. A. Rose, *Physics of Plasmas*, **4**, 4189, (1997)

2. S. Ghosal and H. A. Rose, *Physics of Plasmas*, **5**, 775, (1998)

TU09

Interpretation of Long-Scale-Length Plasma Characterization Experiments on OMEGA

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Recent long-scale-length plasma experiments on OMEGA using exploding foils have provided indications that plasma conditions representative of direct drive designs for the NIF have been attained. Raman scattering data point to densities around 0.15 critical being maintained for times of order 1 ns, consistent with predictions of the two-dimensional code *SAGE*, which also predicts scale lengths close to 1 mm. Line ratios from spectroscopic tracer layers indicate that the electron temperature reaches ~3 keV, close to but slightly lower than code predictions. This presentation examines the sensitivity of the predicted conditions to changes and uncertainties in the experimental parameters and explores the variations in plasma conditions that can be generated. Generally, the plasma parameters are more favorable now that phase plates have been installed on all OMEGA beams. According to *SAGE*, the long-lived density on the axis is fed by the flow of off-axis mass from the (less-irradiated) edge of the foil, an effect that works better with the spatial profile produced by the phase plates; however, the predicted bumps in the time history of the maximum on-axis density are not seen experimentally.

Prefer oral session

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TU010

Electron Temperature and Density Measurements of Long-Scale-Length, Laser Produced Plasmas on OMEGA

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The electron temperature and density of long-density-scale-length (1 mm) CH plasmas created with the OMEGA laser system have been diagnosed using x-ray spectroscopy and stimulated Raman scattering. The plasmas were produced by irradiating mass-limited 18- to 20-μm-thick CH foils on both sides with a total of 20 kJ of laser energy from 38 beams, and are predicted to have electron densities of 10% to 20% critical and electron temperatures of 3 to 4 keV for a duration of about 1 ns. These plasmas have conditions similar to those of the coronal plasmas predicted for direct-drive NIF implosions.

X-ray spectra of embedded high-Z microdots were recorded with a streaked crystal spectrometer and a high-resolution, time-integrated crystal spectrometer. The electron temperature was determined using the measured line ratios of the hydrogen- and helium-like charge states of Ca and Ti. The evolution of the peak electron density was diagnosed using the temporally resolved measurement of the stimulated Raman scattering spectrum. Electron temperatures in the range of 3.5 to 4.0 keV and electron densities of 15%–20% critical were measured.

Innocuous here. Calculate photo-exc- effects. Perhaps he does an escape factor, of some kind. He does not do it, certainly not in 2-D

Prefer oral presentation

This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

TU011

Stimulated Brillouin Backscattering in NIF Direct-Drive Scale Plasmas

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Stimulated Brillouin backscattering (SBS) has been studied in NIF direct-drive–scale plasmas created with the OMEGA laser system. CH plasmas with density gradient lengths of ~1 mm and electron temperatures in excess of 3 keV have been created using staggered sets of beams. These plasmas have been created by exploding foils, with a maximum on-axis density of 15% of the critical density, and by irradiating thick solid targets. The scale lengths and temperatures are predicted to be similar in the two plasma conditions except that the thick, solid target plasma always has a critical density surface.

Initial measurements of stimulated Brillouin scattering (SBS) in the exploding foil plasmas show that SBS is completely inhibited up to average intensities of $\sim 1.5 \times 10^{15}$ W/cm^2 when distributed phase plates (DPP's) are used. When the DPP is removed from the interaction beam, the SBS reflectivity can exceed 10%. In this latter case, the backscattered spectrum shows three distinct features: a broad feature associated with the turn-on of the interaction beam pulse; a strongly blue-shifted feature that can be explained by SBS and pump depletion of the hot spots of the interaction beam; and a "filamentary" structure, which appears to move with the plasma flow velocity.

Prefer oral session.

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Laser-plasma interaction experiments in a single hot spot*

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Interaction experiments using realistic lasers are often difficult to interpret, even for well-defined plasma conditions, since the laser beam intensity and phase structure are complicated. Parametric instabilities such as stimulated Raman scattering (SRS), stimulated Brillouin (SBS) scattering, and self-focusing can occur to varying degrees within individual "hot spot" structures in such laser beams, and it is uncertain how instabilities produced in an ensemble of hot spots might couple with each other. This further complicates understanding of the onset and non-linear behavior of these instabilities. These issues are unavoidable in interpreting experiments using random phase plate (RPP) smoothed laser beams. Experiments studying the interaction from a single hot spot, such as from a diffraction limited laser beam, might overcome many of these issues.

We have begun a series of experiments using the Los Alamos Trident laser facility to study SRS, SBS, and self-focusing in a diffraction limited (single hot spot) laser beam. A separate heater beam is used to create a quasi-homogeneous, large scale, hot plasma with $T_e \sim 0.5$ keV, $L \sim 1$ mm. A diffraction limited beam interacts with the plasma, and the plasma density and acoustic damping are systematically varied. The laser intensity profile is well-defined as a diffraction-limited speckle, whose width is $\sim f\lambda$, and length is $\sim 8 f^2\lambda$, where f is the f-number of the focusing optic, and λ is the laser wavelength. The parameters for the diffraction limited laser are $\lambda = 527$ nm, 200 psec, f / 7, and the intensity can be varied between 10^{14} - 10^{16} W/cm^2. The transmitted beam angular distribution is measured to indicate the activity of self-focusing and beam steering, and SRS and SBS backscattered light are measured. Since the laser has a single well-defined intensity, the instabilities can be studied in regimes where only one or a combination of the instabilities are active by varying the laser and plasma conditions. We will discuss the experimental configuration, will describe the details of the laser and plasma conditions, and will present initial experimental results.

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*Work performed under the auspices of the U.S. Department of Energy by Los Alamos National Laboratory under contract W-7405-ENG-36.

TU013

Twenty-Eighth Annual Anomalous Absorption Conference
Bar Harbor, Maine
14-19 June, 1998

Measurements of density fluctuations and beam-spray in a large scalelength Nova gasbag plasma using near forward laser scattering

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We describe measurements of near forward scattered laser light in a Nova gasbag plasma. These measurements provide a way to investigate plasma density fluctuations and beam-spray of the forward directed light which produces the x-ray drive in a NIF-like hohlraum. Time resolved spectral and time integrated amplitude detectors measure the characteristics of the near forward scattered light from an f/4.3 351 nm probe beam propagating through a 2mm $n_e/n_{cr} = 0.07$ to 0.11 plasma at about $T_e = 2.5$keV. The probe intensity ranges from 1.5 to 13×10^{15} W/cm^2. The detectors extend in angle from 6° to 35° off the forward direction. We observe classical to strongly driven stimulated Brillouin forward scattering (SBFS) and an intensity dependent angular and spectral broadening of the probe beam. We find that the angular spread in the near forward scattered light at low intensities can be explained with density fluctuations having $< |\delta n/n| > \sim 0.005$ and a transverse correlation length of $l_\perp \sim 1.5\mu$m. At higher intensities, the fluctuation amplitude increases to $< |\delta n/n| > \sim 0.03$ with $l_\perp \sim 0.5\mu$m. Initial forward scattering measurements using a 263 nm probe at 1×10^{14} W/cm^2 show a background fluctuation level of $< |\delta n/n| > \sim 0.002$ with $l_\perp \sim 1.5\mu$m. A subaperture f/8 probe beam produces greater beam spray than the f/4.3 beam; however, NIF ignition simulations show that the capsule asymmetry introduced by applying the largest measured beam spray to all of the NIF beams can be tuned out by adjusting the relative power in the inner and outer beam cones.

*Work performed under the auspicies of the U. S. Department of Energy by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48.

Prefer Oral Session

Send John the Statistical [illegible] paper. Single scattering events off clusters causing [illegible].

REVIEW TALK

J. Meyer, Chair

Tuesday, 16 June 1998

Parametric Instabilities and Thompson Scattering: A Perfect Marriage

H. A. Baldis

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28th Annual Anomalous Absorption Conference
14-19 June 1998
Bar Harbor, Maine

Abstract

"Parametric Instabilities and Thomson Scattering: A Perfect Marriage"

by
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Twenty years ago, at the Anomalous Absorption Conference in Tucson, the first application of Thomson Scattering to the study of waves on laser plasmas was presented. Thomson Scattering, as a diagnostics, provided the first direct observation of electron plasma waves driven by the two plasma decay instabilites. During the following years this diagnostic has become the most powerful tool for the study of the intricate game played by the plasma waves driven by different parametric instabilities. Traditionally a diagnostic for thermal properties of plasmas, technical advances on the implementation of Thomson scattering, has made this the sine qua non diagnostic for plasma waves. In this talk we will review our present understanding (or lack of it) of scattering instabilities through the eyes of Thomson Scattering.

Work performed under the auspices of the U.S. DOE by the Lawrence Livermore National Laboratory under contract no. W-7405-ENG-48.

of

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MIXED POSTER SESSION

Tuesday, 16 June 1998

TUP1

Twenty-Eighth Annual Anomalous Absorption Conference
Bar Harbor, Maine
14-19 June, 1998

Linear and Nonlinear Pinhole Plasma Physics in NIF Spatial Filters

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C. D. Boley[4], K. G. Estabrook[4] and R. P. Ratowsky[4]

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We present new results describing the propagation and interaction of high intensity laser beams in plasmas that are characteristic of various pinhole designs envisaged for the NIF spatial filters. We concentrate on three physical phenomena: 1) Kinetic (Fokker Planck) simulations of the plasma evolution with various ionization models and comparisons with strictly fluid codes. Specifically, Ta and Fe plasmas are modeled in order to compare the resulting density and temperature profiles obtained from the various codes. 2) A nonlinear analysis of the laser beam as it propagates in a realistic pinhole plasma and backscatters. We present density and intensity profile criteria which demarcate the stability boundary for significant stimulated Raman backscatter. We use anisotropic and non-Maxwellian electron velocity distribution functions that are characteristic of pinhole plasmas. 3) We use 2D and 3D spectral beam propagation codes to simulate the evolution of the laser electric field inside pinhole plasma density models derived from interferometry data or fluid simulations and compare the electric field's amplitude and phase to those due to vacuum propagation. Our aim is to establish strict criteria for acceptable levels of phase distortion under different plasma conditions which will occur in NIF pinholes. Novel pinhole designs will also be shown which offer interesting new methods of avoiding the formation of sufficiently high density and long scalelength plasmas in 20 or 22 nanoseconds.

*This work is performed under the auspicies of the U. S. Department of Energy by the Lawrence Livermore National Laboratory under contract number W–7405–ENG–48. The work of R. P. J. T. was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460 and the University of Rochester.

Prefer Poster Session

TUP2

EOS DATA EXPERIMENTS FOR CH FOAMS USING SMOOTHED LASER BEAMS

A. Benuzzi(1), M. Koenig(1), B. Faral(1), F. Philippe(1), D. Batani(2), F. Scianitti(2), L. Müller(2), F. Torsiello(2), T. Hall(3), N. Grandjouan(4), W. Nazarov(5).

(1) *LULI, CNRS, Ecole Polytechnique, France*
(2) *Univ. of Milan, Italy*
(3) *Univ. of Essex, UK*
(4) *LPMI, CNRS, Ecole Polytechnique, France*
(5) *Univ. of Dundee, Scotland*

Porous materials studies are of great importance in ICF physics, eg, as a way to suppress laser nonuniformities[1], in material physics[2] or in astrophysics. Indeed in this last case, foams have already been used to simulate supernovae remnants[3]. Therefore the knowledge of foams Equation of State is needed. Here we present the very first EOS data of CH foams obtained with lasers. The data, around 0.5 Mbar, have been obtained by reverse mismatch impedance technique, using aluminium as the reference material and foams with densities ranging from 50 to 200 mg/cc. A specific target design allows to measure shock velocities in aluminium and in foams on the same shot. The results are compared to SESAME EOS which includes the initial low density effects.

[1]M. Dunee et al, Phys. Rev. Lett. 75,3858 (1995)
[2] N. Holmes, Proceedings of APS Topical Conference on Shock Compression of Condensed Matter, Colorado Springs USA (1994)
[3]B. Remington et al., Phys. Plasmas **4** (5),1994 (1997)

TUP3

DYNAMICS OF AXIAL PLASMA FLOWS IN LASER-INDUCED HOT SPOTS*

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The interaction of an intense laser beam with an underdense moving plasma has recently been investigated for the case of flows transverse to the direction of laser propagation (e.g., S. Ghosal and H. Rose, *Phys. Plasmas* **4**, 2376, 1977), as a possible mechanism to explain the apparent deflection of laser beams frequently observed in ICF hohlraum experiments. In this paper we study the plasma response to the laser ponderomotive force (PMF) at the opposite extreme - namely, that in which the flow is nearly parallel to, and in particular oppositely directed to, a focused laser beam. Such counterstreaming flows may be commonly encountered both in tetrahedral hohlraum geometries and in direct drive scenarios when a laser beam is nearly normally incident upon the target surface; moreover, PMF effects will be especially pronounced when the laser focal spot is in the underdense region of the supersonic plasma blowoff.

We consider the effect of a supersonic axial flow on a single hot spot that might arise from a smoothing phase mask placed in a diffraction-limited focused laser beam. To analyze the resulting beam-plasma interaction and flow pattern, we have intercompared predictions from 1) a linearized analytical hydrodynamic model, 2) the fully nonlinear fluid code LASNEX (run in an Eulerian mode), and 3) a hybrid PIC code. These simulations show that weak disturbances are generated in the hot spot and propagate radially outward as they are swept downstream, leading to spatially extended density and velocity "streamers" trailing off into the wake of the hot spot. The implications for the propagation of the beam in the presence of these density and velocity fluctuations are explored.

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TUP4

UCRL-JC-130324 Abs.

28th Anomalous Absorption Conference
Bar Harbor, Maine, June 15-19, 1998
Abstract for Poster Presentation

Diagnosis of the propagation of a blast wave generated by the Petawatt laser system[1]

K. S. Budil, B. A. Remington, D. M. Gold, K. Estabrook, R. Lerche, P. M. Bell, J. A. Koch, J. Kane, D. Pennington, C. Brown, M. Key, and M. D. Perry

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We will report on a diagnostic to measure the trajectory of a blast wave propagating through a plastic target 250-500 μm thick. This blast wave is generated by the irradiation of the front surface of the target with ~ 400 J of 1 μm laser radiation in a 5-20 ps pulse focused to a roughly 50 μm diameter spot, which produces an intensity in excess of 10^{19} W/cm^2. These conditions approximate a point explosion, and a blast wave is predicted to be generated with an initial pressure ~ 1 Gbar which decays as it travels approximately radially outward from the interaction region. We have utilized streaked optical imaging of the radiation from behind the blast front to determine its time of arrival at the rear surface of the plastic. By varying the thickness of the plastic, a trajectory can be established. A self-similar Taylor-Sedov blast wave solution will be applied to the results of LASNEX simulations. The experimental setup, LASNEX design simulations, and initial results will be shown.

[1]This work was performed by Lawrence Livermore National Laboratory under the auspices of the U.S. Department of Energy under Contract No. W-7405-ENG-48.

28th Anomalous Absorption Conference *Bar Harbor (Maine), June 1998*

GROWTH OF STIMULATED RAMAN SCATTERING IN THE PRESENCE OF SHORT-WAVELENGTH DENSITY MODULATIONS

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Stimulated Raman scattering (SRS) of light waves by an underdense plasma can be perturbed by density modulations induced by stimulated Brillouin back-scattering (SBBS). These modulations with wave-number $2k_0$ generate electron plasma waves[1] with multiple wave-numbers $k_p \pm 2mk_0$ (m integer) which cause an enhancement of Landau damping[2,3].

In this paper, the SRS threshold and growth rate for back-scattering geometry are investigated in ICF relevant conditions, as a function of the electron temperature T_e in the range [0.5 -3] keV, the electron density n_e in the range [0.05-0.25] n_c (n_c: critical density for incident laser wavelength) and the density modulation $\delta n_e/n_e$ in the range [0.5-30] %. The results come from the numerical resolution of the dispersion relation in both kinetic and hydrodynamic frameworks. For both models, the competition between the harmonic coupling (controlled by the ratio $\delta n_e/T_e$) and strong Landau damping (controlled by T_e/n_e) leads to a minimum of SRS threshold for an intermediate density : 0.12 and 0.2 n_c for $\delta n_e/n_e$ = 10 % and T_e = 1 and 3 keV, respectively. Differences between the two models are pinpointed. An analytic fit of the SRS growth rate in modulated plasma is provided, which well reproduces the numerical results in the above-mentionned ranges of parameters.

[1] *P. K. Kaw, A. T. Lin, J. M. Dawson, Phys. Fluids* ***16****, 1967 (1973)*
[2] *H. G. Barr, F. F. Chen, Phys. Fluids* ***30****, 1180 (1987)*
[3] *G. Bonnaud, D. Pesme, R. Pellat, Phys. Fluids* ***B 2****, 1618 (1990)*

Abstract for a Poster at the
Anomalous Absorption Conference, Bar Harbor, Maine, 14-19 June 1998

Fast Electron Generation by Intense Laser Pulses in Underdense Plasma

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In the self-modulated laser wakefield accelerator (LWFA) [1], a multi-TW, sub-ps laser pulse propagates through an underdense plasma ($n_0 \simeq 10^{19}$ cm^{-3} with a laser wavelength of $\lambda \simeq 1$ μm), such that the laser pulse length L extends over several plasma wavelengths $\lambda_p = 2\pi c/\omega_p$, and the power P exceeds the critical power for relativistic self-focusing $P_c = 17(\lambda_p/\lambda)^2$ GW. When $L > \lambda_p$ and $P > P_c$, the laser pulse undergoes a strong self-modulation or forward Raman instability that generates a large amplitude plasma wave (wakefield) with phase velocity $v_p \simeq c$. This wakefield can accelerate electrons to high energy. Accelerated electrons self-trapped from the background plasma have been observed in recent experiments with energies as high as 100 MeV [2,3]. One possible mechanism for self-trapping is wave-breaking of the wakefield [4]. However, analysis and simulations have shown that self-trapping can occur at wakefield amplitudes significantly below wavebreaking from the interaction of the wakefield with a slow phase velocity ($v_p \ll c$) wave [5]. In the self-modulated regime, the slow wave is produced by the beating of the laser field with Raman backscattered light. The beat wave can trap low energy electrons from the plasma and inject them into the wakefield for acceleration to high energy. In the standard LWFA ($L \simeq \lambda_p$, $n_0 \simeq 10^{17}$ cm^{-3}), injection of electrons from the background plasma can be achieved with three pulses [6]: An intense drive pulse to generate the wake, and two counter-propagating injection pulses that collide behind the drive pulse. When the injection pulses collide, they create a slow phase velocity beat wave that can inject electrons into the fast wakefield. This can result in the generation of fs electron bunches with small ($\leq 1\%$) energy spreads.

This work was support by DoE and ONR.

[1] For a review, see E. Esarey et al., IEEE Trans. Plasma Sci. **PS-24**, 252 (1996).
[2] C.I. Moore et al., Phys. Rev. Lett. **79**, 3909 (1997).
[3] D. Gorden et al., Phys. Rev. Lett. **80**, 2133 (1998).
[4] K.C. Tzeng et al., Phys. Rev. Lett. **79**, 4194 (1997).
[5] E. Esarey et al., Phys. Rev. Lett., submitted (1998).
[6] E. Esarey et al., Phys. Rev. Lett. **79**, 2682 (1997).

LASNEX simulations of 4 astrophysical phenomena: supernova shocks, plasma jet, micrometeor cratering and blast wave on the Nova and PetaWatt lasers.

Kent Estabrook,[1] R.Paul Drake,[2] Bruce Remington,[1] Gail Glendinning,[1] Kim Budil,[1] James Stone,[3] Dave Farley,[1] Michael Wood-Vasey,[4] D.H.Munro,[1] L.J.Suter,[1] J.H.Harte,[1] G.B.Zimmerman,[1] D.S.Bailey,[1] Jave Kane,[1] Russel Wallace,[1] R.A.London,[1] A.M.Rubenchik,[1] Dmitri Ryutov,[1] S.V.Weber,[1] S.P.Hatchett[1] and R.McCray.[5] [1]*Lawrence Livermore National Laboratory,* [2]*U.Michigan, Ann Arbor,* [3]*U.Maryland, College Park,* [4]*Harvey Mudd,* [5]*U.Colorado, Boulder.*

1) The LLNL Nova laser simulates an astrophysical supernova collision with the residual gas from the initial red or blue giant. Hohlraum x rays of Tr$\sim$220drive[1] eV ablate and accelerate 200 microns of $C_8H_7Br_1$ across a 150 micron gap into SiO_2 foam (mass density .04) driving forward and reverse shocks[2]. We compare experiment to LASNEX. [1] B.A.Remington et al. PRL 67, 3259 (1991). [2] R.P.Drake *etal.* Ap.J.Lett. (1998) in press.

2) Radiation drive ablates a hemispherical $C_{50}H_{48}Br_2$ plastic shell which implodes to form a density compression of order 10 g/cm^3. This asymmetric compression jets into carbon foam of initial density .1 g/cm^2 with velocities $\sim$3x10^7 cm/sec and pressures > 100 MBar. This can be used to test astrophysical codes for much larger jets.

3) We simulate an micrometeor collision with a spacecraft by means of PetaWatt on the Nova laser. In a $\sim$ picosecond PetaWatt deposits $\sim$ 300 Joules onto gold in radius 40 microns. The shock wave and fast electrons melt the gold and form a crater which then freezes. We compare LASNEX to experiment.

4) PetaWatt focuses $\sim$300 Joules of 1.053 micron light in $\sim$2 picoseconds onto a 22 micron radius spot. Intensities of order $10^{19} W/cm^2$ produce $\sim$400 keV electrons. The target is 5 microns of CH followed by .5 microns of aluminum followed by 400 microns of CD_2. The heated material blows out towards the laser driving a radial shock wave. After several nanoseconds the blast wave blows through the other side to glow as detected by a streak camera.

Auspices U.S.D.O.E. by LLNL Contract W-7405-ENG-48

Abstract submitted to the 28th Anomalous Absorption Conference, Bar Harbor, Maine, June 14-19, 1998

poster please.

TUP8

Twenty-Eighth Annual Anomalous Absorption Conference
Bar Harbor, Maine
June 14, 1998

Study of the Saturation of Stimulated Raman Scattering by Secondary Decays

C.G.R. Geddes, R.K. Kirkwood, S.H. Glenzer, K. G. Estabrook; LLNL
C. Joshi, K.B. Wharton; UCLA

Experiments are under way at the NOVA laser to characterize saturation of the stimulated raman scattering (SRS) langmuir wave by secondary decays. Recent experiments have shown that SRS is limited by saturation of the SRS langmuir wave, and that the saturation level is dependent on ion acoustic wave parameters in the plasma [1,2]. Two processes in which the langmuir wave amplitude is limited by decay of the langmuir wave into an ion wave and a third wave are likely candidates to explain this behavior. In the electromagnetic decay instability (EDI), the third wave is an electromagnetic wave. In the langmuir decay instability (LDI), the third wave is a langmuir wave. Previous experiments [3] have detected a langmuir wave attributed to LDI, but neither ion wave has been detected, and no comparison of the two instabilities has been attempted.

We will measure the product ion and langmuir waves from the decay of SRS pumped by 3ω and 2ω (351 and 527nm) beams respectively using Thomson scattering of NOVA's 4ω (263 nm) probe beam to resolve the waves' κ and ω. Each of the product waves has a κ and ω which are distinct from other waves (ie SBS ion waves), allowing identification of the instability(s) important to the saturation of SRS. Understanding these decay processes will help to provide a physical basis for the understanding of SRS scaling, and will improve confidence in the design of ignition experiments. The experimental program and preliminary results will be presented.

[1] R. K. Kirkwood et. al., Phys. Rev. Lett. 77, 2706 (1996). and J. C. Fernandez et. al. Phys. Rev. Lett. 77, 2702 (1996).
[2] R. K. Kirkwood et. al., submitted to Phys. Rev. Lett.
[3] C. Labaune et. al., Phys Plasmas, 5(1), 234 (1998). and K.L. Baker et. al., Phys. Rev. Lett., 77(1), 67 (1996)

*This work was performed under the auspices of the United States Department of Energy by the Lawrence Livermore National Laboratory under Contract No. W-7405-ENG-48

We request a poster session.

Abstract submitted to the 28th Annual Anomalous Absorption Conference
14-19 June, 1998, Bar Harbor, Maine

Experimental Study of Visible and Near UV Harmonic Generation from the Interaction of an Ultra Short Pulse Laser with a Solid Target†

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We have experimentally investigated the production of visible and near ultraviolet harmonics from the interaction of a high intensity, ultra-short pulse laser with a solid density aluminum target. The laser has a wavelength of 800 nm, a pulse length of 130 fs, and is focused with an f/3.6 off axis paraboloid to achieve peak intensities of 1×10^{18} W/cm^2. The scaling of the power emitted in the fundamental as well as the second through fourth harmonics was studied as a function of the incident laser intensity for comparison to theoretical predictions[a]. Experiments were conducted with the incident laser at angles of 17.5° and 22° with respect to the target normal and the harmonics were collected in the specular and near backscatter directions. The laser spot was imaged to the entrance slit of an optical monochromator and a photomultiplier tube or diode array was used as the detector. The PMT signal was time resolved to distinguish the pulsed signal from late-time recombination, while the diode array allowed investigation of the spectral structure of the harmonic lines. The incident polarization was varied continuously between S and P polarizations.

[a]S. C. Wilks, W. L. Kruer and W. Mori, IEEE Trans. Plasma Sci

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TUP10

UCRL-JC-129810 Abs.

High pressure solid state hydrodynamic instability growth experiments on the Nova Laser*

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J. S. Wark - *University of Oxford*
A. A. Hauer - *Los Alamos National Laboratory*
B. Failor - *Physics International*
M. A. Meyers - *University of California, San Diego*

We are conducting experiments on the Nova laser to investigate material strength properties at high pressures by measuring Rayleigh-Taylor instability growth rates. The RT dispersion curve is predicted to be sensitive to the state of the material, with a perturbation growth that is reduced in the solid state compared to the fluid state.[1,2]

An x-ray drive has been developed on Nova to shock compress metal foils to about 3 Mbar at very high strain rates (10^7-10^9), while maintaining the solid state. A high contrast shaped laser pulse generates a low isentrope x-ray drive in an internally shielded scale-2 hohlraum. A package consisting of a 20 μm brominated polystyrene ablator and a 18-19 μm metal (Cu or Mo) foil with a machined modulation at the embedded interface is mounted on the side of the hohlraum. The x-ray drive ablatively launches a sequence of shocks into the foil, compressing it by nearly a factor of 2 at a peak pressure of 3 Mbar and a temperature of 0.25 eV (below the melt temperature). During the acceleration, the embedded interface is unstable, and it undergoes Rayleigh-Taylor growth. We use x-ray radiography to measure the growth rate and demonstrate the effect of material strength.

In support of the instability growth experiments, we are developing dynamic Bragg diffraction on the Nova laser. A keV x-ray backlighter source is diffracted from the lattice planes of a crystal sample mounted on the side of an internally shielded hohlraum. The x-ray drive launches a shock into the crystal, which then propagates through to the rear surface. A shift in the diffraction angle of x-rays provides information about the shock wave profile as it breaks out from the rear surface of the sample. We have done experiments using Si crystals at shock pressures of 200-500 kbar.

We will present results of our low adiabat x-ray drive development, and discuss the instability growth experiments and modeling. We will also describe the dynamic diffraction technique and how we are using it to study the material state under shock compression.

*Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48.

[1] J. F. Barnes *et al.*, J. Appl. Phys. 45, 727 (1974).
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28th Anomalous Absorption Conference

The Significance of Stimulated Brillouin and Raman Backscatter from the Target as a Source for Optics Damage in NIF/LMJ Lasers.

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We are assessing the possibilities for damage to the silica vacuum window and to mirrors and other optical elements in the NIF/LMJ lasers due to stimulated Brillouin and Raman backscatter from the target. Spatial and temporal modulations in the backscatter would increase the damaging fluences above the average. If the backscatter were phase-conjugated, there would be no spatial modulation of the backscatter amplitude at the near field. However, according to calculations with the laser-plasma modeling code F3D, the backscatter is not phase conjugated but shows speckle structure in the near field and is well collimated. Therefore some fraction of the near field intensity is well above the incident intensity. Time dependence of the backscatter may mitigate thermal damage by moving the bright speckles and might stabilize filamentation in the silica. This work is ongoing and will be fully reported at the meeting.

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prefer poster presentation

TUP12

Theory of the Linear Feed-Out in Planar Geometry

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The propagation of a small perturbation from the back to the front surface of a laser-illuminated planar foil is investigated both analytically and numerically. The foil is described by a single compressible fluid accelerated by a sudden overpressure on the front surface. The latter is flat while the back surface is rippled. When the initial shock reaches the back surface, a rarefaction wave propagates backward toward the front. The rippled rarefaction wave transfers the perturbation from the back to the front. Once the front becomes rippled, the Rayleigh–Taylor instability is seeded and the perturbation could grow rapidly. The analytic theory is developed by solving the linearized compressible fluid equations in a Lagrangian frame of reference. The equations cannot be solved exactly inside the rarefaction wave; an approximate solution can be found, however, when the ripple wavelength $(\lambda = 2\pi/k)$ is longer or shorter than the in-flight foil thickness (d). Then the ripple temporal evolution is determined by matching the solutions inside and outside the rarefaction wave. The analytic solution is compared with the results of 2-D Lagrangian numerical simulations. The code used in the simulations is based on the explicit second-order difference scheme with assigned pressures on both surfaces. Dependencies of the rippled amplitude on wavelength and foil thickness have been obtained for the cases ($kd < 1$ and $kd > 1$).

Prefer poster session.

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EFFECTS OF INDUCED SPATIAL INCOHERENCE ON STIMULATED BRILLOUIN BACKSCATTERING

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The transient growth of SBS in a given three dimensional cylindrical hot spot of finite life-time is computed analytically in both standard decay (weak coupling) and modified decay (strong coupling) regimes. A uniform expression for the instantaneous backscattered power, valid for any time and any hot spot intensity is proposed. This expression makes it possible to compute the energy backscattered from a single hot spot during its life-time (or "microscopic" backscattered energy). It is shown that the finite transverse size of the hot spot leads to important diffraction effects that can significantly reduce the hot spot backscattered energy.

In the case of "Induced Spatial Incoherence" (ISI), the spatio-temporal speckle statistics is investigated numerically. In the frame of the independent hot spot model, the "macroscopic" reflectivity $R(\langle I\rangle,\tau_c)$ is obtained by averaging the "microscopic" backscattered energy over this ISI speckle statistics. Here $\langle I\rangle$ and τ_c respectively denote the average intensity and the coherence time of the ISI field. Comparisons are made with 2D and 3D numerical simulations which take into account both SBS and self-focusing/filamentation processes.

TUP14

Submitted to the 28th Anomalous Absorption Conference, June 1998

Comparison of different optical smoothing methods for reduction of filamentation of laser beams in ICFcontext

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The choice of the optical smoothing method will be a key element for the sucess of the MegaJoule Laser project. By reducing filamentation, a better homogeneity of laser irradiance can be obtained on target, and Raman and Brillouin scattering can be indirectly reduced. To adress this topic, we have developped a 3D code that simulates the propagation of a light beam, within the framework of the paraxial approximation. The plasma behavior is represented by a density modulation induced by the beam ponderomotive force. Our main diagnostic is the proportion of energy situated above 5 times or 10 times the average energy. The simulations are performed with parameters relevant to present holraum (T_e = 3 keV, n_e/n_c = 0.1, I_0 = 2.10^{15} W/cm^2). Firstly, the influence of a Kinoform Phase Plate is compared to the Random Phase Plate case. Secondly, for the Smoothing by Spectral Dispersion method used on Nova, the influence of the dimension of SSD (2DSSD / 1DSSD) is studied. The improvement brought by the 2D version of SSD is quantified in term of equivalent bandwidth in 1D. The influence of the ratio between the two modulation frequencies in the 2D case is also investigated. Finally, the SSD method is compared to the Smoothing by Optical Fiber method used on the French laser Phebus, for parameters for which the loss of energy by frequency tripling are small and comparable for both methods.

Poster presentation preferred

28th Annual Anomalous Absorption Conference,
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Investigation of fusion neutrons produced in the focus of a 200-mJ Ti:Sapphire laser

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ABSTRACT

Experimental and theoretical results are presented which show the production of fusion neutrons in the focus of a table-top, 10-Hz repetition rate Ti:Sapphire laser.

In the experiments, laser pulses (typically with pulse energies of 200 mJ and durations of 150 fs at 790 nm) were fucused on a target consisting of a deuterated polyethylene foil. Neutrons were observed with a strong monoenergetic component around 2.45 MeV which is clear evidence that they are products of the d (d, n) ^{3}He fusion reaction. A substantial number of MeV-range-γ-rays was also observed. The application of a well-defined prepulse proved to be crucial for generating the neutrons, which shows that it is necessary to focus the main pulse into a preformed plasma.

Numerical simulations confirm the experimental results and reveal the mechanisms involved: The occurence of fusion neutrons is attributed to the formation of a relativistic plasma channel in the laser focus. A large fraction of the electrons within this channel are ejected with relativistic velocities, which subsequently causes the channel to expand radially in a kind of explosion. Thus, deuterium ions are accelerated up to energies of a few 100 keV, which makes fusion possible with ions in the preplasma.

Further experiments characterizing the released neutrons and the conditions for their production are also reported, and future experiments and applications are discussed.

TUP16

Wave kinetic formulation of neutrino and photon driven forward stimulated scattering instabilities

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Abstract

We present a general description of the forward stimulated scattering instabilities of an intense neutrino field, with an arbitrary energy distribution and angular spread, propagating in a dense plasma. The neutrino field is described by a distribution of quasi-particles in phase space (neutrino number phase-space density $\mathcal{N}_k$). The single neutrino quasi-classical dynamics is governed by an effective Hamiltonian, including the electroweak interaction with the electrons of the background plasma, and the time evolution of $\mathcal{N}_k$ is determined by a neutrino Klimontovich equation. The neutrino distribution is modulated by the Langmuir waves and these in turn are driven by the ponderomotive force of the neutrinos in the background plasma.

Using this formalism we derive the general dispersion relation for the Langmuir waves. In the neutrino fluid limit, we derive the threshold and growth rate for forward stimulated Raman scattering of a neutrino beam, while in the neutrino kinetic limit we calculate the neutrino Landau damping growth rate. Generalization to a neutrino distribution emitted from a spherical surface is also considered. We show that in this case the growth rate is reduced. Inclusion of collisional damping and electron Landau damping is discussed. Implications of these results on supernovae dynamics are presented.

The same approach is extended for photon driven forward stimulated Raman scattering. The growth rates for forward stimulated Raman scattering are recovered, thus showing that this formalism can provide an efficient and powerful tool to treat the propagation of electromagnetic waves, with a broad frequency spectrum and an arbitrary angular spread, in underdense plasmas.

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Schedule Change: Please insert this abstract in your abstract book in Tuesday's Poster Session Section. Please note it has been replaced in Wednesday's oral session by "Polarization and Spectral Dispersion Smoothing: Effects on SBS, SRS, and filamentation."

Abstract submitted to the 28th Anomalous Absorption Conference

A Parallelized Laser Ray Tracer for ICF3D

T. B. Kaiser, J. L. Milovich, M. K. Prasad and A. I. Shestakov

ICF3D is a parallel unstructured mesh 3D code being developed for ICF physics modeling. It consists of several packages: hydrodynamics, heat conduction and laser ray tracing and power deposition. Here, we will discuss details of the laser package. It consists of a user-specifiable beam source and ray casting able to handle propagation to and through an arbitrary 3D material. The integrator can be used in first (constant index of refraction in a cell) or second (linear variation of the index of refraction) order modes. The second order mode is needed to obtain the correct trajectories when gradients are not aligned with the coordinate directions. It is fully parallelized using MPI (message passing interface) and domain decomposition. To achieve load balance, rays are processed in chunks and delivered to the appropriate processors (PEs) as they cross the interprocessor boundaries. This procedure permits other processors to participate in the computation while successive chunks of rays are processed. We present results on scalability to large number of PEs. Calculations involving the coupling with other physics packages in MPP simulations will also be presented.

Abstract submitted to the 28^{th} Anomalous Absorption Conference

LARGE-SCALE FILAMENTATION SIMULATIONS WITH YF3D*

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The larger path lengths for laser-plasma interactions present in NIF hohlraum designs lead to increased gain for filamentation as well as SBS and SRS. Direct simulation of a larger plasma volume has been impractical because of computational limitations. However, the advent of the recent ASCI Blue Pacific TR machine has enabled simulation of a plasma volume comparable to one beam in a NOVA hohlraum ($300\mu m \times 300\mu m \times 1mm$). To make use of this resource, we have developed a new version of F3D to run on distributed memory MPP machines. At present, we include a nonlinear Eulerian hydrodynamics package (with linearized nonlocal heat conduction) coupled to a paraxial light wave solver, and include beam models for spatial smoothing by random phase plates (RPP) and temporal smoothing by spectral dispersion (SSD).

In this presentation, we will report on the MPP version of the F3D code, and present results from filamentation simulations using NIF ignition parameters ($I_0 = 2 \times 10^{15} W/cm^2$, $T_e = 4$ keV, $T_i = 2$ keV, $n_e/n_c = .1$) performed on ASCI Blue at Livermore.

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TUP18

Fluorescence based visualization/diagnosis of laser driven radiation-hydrodynamics experiments

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Predictions of highly efficient sources of multi-keV x-rays have recently been corroborated by experiments. Here we discuss the prospect of using similar multi-keV sources to perform fluorescence-based diagnostics on future high power lasers, such as the National Ignition Facility (NIF). Such a capability could provide us with a qualitatively new way of diagnosing radiation hydrodynamics experiments. Of particular interest is the prospect of imaging a slice through an experiment using a thin sheet of multi-keV x-rays to photo-excite a slab of appropriately doped material within the target. By viewing the fluorescence emission from the side, we can obtain "cut away images" both for direct observations and for comparison against theoretical predictions. Additionally, we may be able to take advantage of the shift in fluorescent emission that occurs when outer electrons are ionized, to visualize the temperature of the material within the slice. This technique would be analogous to current diagnosis of transparent fluids using a thin laser sheet to pump optical fluorescence.

In this paper, we review the current state of high efficiency/high brightness sources; develop a scaling for measured fluorescent signal as a function of resolution (and other parameters); and provide examples of how the technique might be used to visualize a variety of radiation hydrodynamics of various experiments. In, roughly, increasing order of source brightness requirements, these include: supersonic and trans-sonic heat flow; very non-linear hydrodynamic instability growth in 2D planar foils; bulkplasma evolution in hohlraums; capsule implosion symmetry and, ultimately, visualization of non-linear 3D hydrodynamic instabilities in capsules. We discuss the multi-keV pumping source requirements for each type of experiment and compare it to our current, projected capabilities with NIF. Finally, we discuss a proof-of-principle experiment which we may be able to field on the Omega laser.

28-th Annual Anomalous Absorption Conference

Theory of nonlocal transport for low-Z plasmas

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We have developed a theory of nonlocal electron transport which is valid for arbitrary ratio between the electron mean free path and the characteristic spatial scale of small amplitude potential perturbation. Earlier developed nonlocal theory for high-Z plasmas [1] has been generalized for a plasma with an arbitrary ion charge since the electron-electron collisions are described with the exact collision integral in the Landau form. We have calculated the potential parts of Fourier components of all electron fluxes and the correspondent transport coefficients such as electrical conductivity, thermal conductivity, thermocurrent coefficient, and ion convection coefficients. These coefficients agree with the conventional transport coefficients found by Spitzer and Härm and Braginskii [2] in the strongly collisional limit, however they depend on the perturbation wave number and translate to the Landau damping in the collisionless limit. Possible applications of this theory are illustarted in two examples: the heat transport inhibition if a weakly collisional plasma and the ion acoustic wave damping in the semicollisional limit. Our results quantitatively agree with the direct Fokker-Planck simulations [3], although they have quasi- analytical form and may be utilized in different hydrodynamic programs.

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Study of x-ray image characteristics in short pulse high intensity laser plasma interaction

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The scheme of fast ignition originated by Tabak et al.[1] requires hole boring and hot electron production with an intense short pulse laser. At the Lawrence Livermore National Laboratory (LLNL) the characteristics of the hot electron source at laser intensities 10^{18} W/cm^2 - 10^{20} W/cm^2 and at pulse width of 0.5 psec - 20 psec have been measured and diagnosis of the heating at depth by hot electrons has been initiated. For 20 psec pulse width experiments targets were exposed to amplified spontaneous emission (ASE) and leakage prepulse before the main pulse. ASE in a typically 3 ns period before the pulse varied in experiments reported here from $2x10^{-5}$ to $2x10^{-4}$ of the main pulse energy. The energy of leakage pulses range from 10^{-4} to 10^{-2} of the main pulse, occurring 2 ns or 4 ns before the main pulse. These prepulse could make preplasmas on targets before main pulse came to targets. To interpret results obtained in hot electron source and heating experiments we need to study and understand high intensity laser propagation in preplasmas. X-ray images of focal spot on the targets were observed with an x-ray pinhole camera and second harmonic spectra from targets were also measured. Laser energy was changed from 200 J to 500 J and the corresponding intensity on target varied from $2x10^{18}$ to $5x10^{18}$ W/cm^2. The laser beam was incident on the target at an angle of 45 degree to the target normal and with P polarization. Aluminum planar targets were chosen for experiments, whose thicknesses were 100-600 μm. Measured x-ray image shapes were different significantly from the optical focal spot image measured with an equivalent plane imaging system. In spectral measurements redshifted second harmonic spectra were observed. This spectral shift might indicate recession of critical density surface[2]. Possible mechanism of laser focal spot modification are discussed.

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Formation of Initial Perturbation of Rayleigh-Taylor Instability in Laser Irradiated Targets

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Hydrodynamic instabilities, such as Rayleigh-Taylor (RT) instability, play a critical role in both inertial-confinement-fusion (ICF) implosions[1] and supernova explosions[2]. In ICF implosions, the RT instability causes hydrodynamic mixing between the hot-spark and the main-fuel, which potentially quenches thermonuclear ignition and burn. In supernova explosions, outer and lower density layers decelerate the expanding motion of inner and higher density layers, causing the hydrodynamic mixing between the two neighboring layers (e.g. H/He interface). This is the most probable explanation why γ rays and x rays from the core material of the supernova SN1987A has been observed in much earlier time than that predicted by spherically symmetric models.

Obviously, initial perturbations of the RT instability have to be characterized to correctly predict the degree of mixing. The initial perturbation in ICF targets are seeded by initial imprint of laser irradiation nonuniformity, in addition to the original target surface roughness. These perturbations are pre-amplified by propagation of rippled shock waves, before the RT instability takes place. The formation of the initial perturbations in ICF targets have been extensively studied under complementary conditions: uniform lasers applied on perturbed targets[3]; and modulated lasers applied on uniform targets[4]. We conjecture that some of the findings in the ICF community may contribute for better understanding of the formation of initial perturbations in supernova explosions.

One possible example is nonuniform neutrino emission from protoneutron stars[4] born at the center of some of supernovae. The neutrino emission may "imprint" its nonuniformity on the hot-bubble that is heated by neutrino. The other example is perturbation growth in the Fe layer pushed by the hot-bubble. Perturbations on the inner surface of the Fe layer may be amplified due to the rippled shock propagation. This situation is analogous to the ICF target, where ablation pressure uniformly pushes the perturbed target surface.

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TUP22

Studies of High Intensity Laser Interactions with Long Scale-length Plasmas

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We have studied high-intensity laser interactions with long scale-length plasmas related to "Fast Ignitor" in Inertial Confinement Fusion (ICF). These laser-plasma interactions are dominated by an enormous photon pressure and relativistic effects resulting from the laser field. Laser light can bore a long scale-length plasma and penetrate into over critical regions. High energy particles are generated by the strong electromagnetic field in the plasmas. From these points of view, we have experimentally studied a laser-channel into the overdense plasma by using 1TW/100ps laser pulses and short pulse intense laser-plasma interaction using a 100TW/0.5ps laser pulse.

Preforming of laser channel in a long scale-length plasma will be required to guide efficiently the intense short pulse laser light into the over dense plasma of the FI. The channel formation was experimentally investigated by using 1μm laser light with a pulse duration of 100ps at 2×10^{17}W/cm^2. Back scattered light spectra, x-ray image and electron density profiles in under and over dense regions were obtained from the interaction plasma accompanied with the channel. Anomalous propagation of laser light into overdense region was observed, which was sensitive to the laser focus position. The focus position would influence on ponderomotive self-focusing in the underdense region and relativistic self-focusing at critical point.

We also examined short pulse laser interactions with a long scale-length plasma including the laser propagation, energy transport and creation of high energy particle by using the 100TW system with a pulse duration of 0.5 ps. Neutrons by D-D reaction in the interaction plasma were measured to diagnose the ion acceleration into target. Neutron yield of 10^6 and its spectra were obtained from a CD target irradiated by the 100TW laser light at intensity of about 10^{19}W/cm^2, indicating the acceleration of high energy ions with MeV energies in the plasma. High energy electrons (MeV) and their transport in the target were also measured by a K-α method.

ORAL SESSION I

S. Wilks, Chair

Wednesday, 17 June 1998

9.4

1998 Anomalous Absorption Conference
Bar Harbor, Maine
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Abstract

Suppression of Electron Blowout and Relativistic Self-Focusing by the Occurrence of Raman Scattering and Plasma Heating

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We use a fully explicit particle-in-cell model to demonstrate that relativistic self-focusing and electron blowout/cavitation can both be suppressed by the occurrence of stimulated Raman scattering (SRS) and plasma heating. The suppression is due to a combination of SRS sidescattering the laser energy out of the focal cone before it can be focused and by intense heating of the plasma. The heating is from a combination of stohastic processes and wave breaking of SRS plasma waves. We give analytic arguments for how a hot plasma can decrease the quiver fluid velocity, which thereby reduces the self-focusing and ponderomotive force. We clearly demonstrate that suppression is possible by rerunning a simulation without letting the electrons move in the laser's propagation direction and by running simulations in which the plasma was initially very hot. Based on the simulation results, we believe that neither cavitation nor appreciable blowout is occurring in many recent experiments.

This work is supported by DOE grant numbers DE-FG03-92-ER40727 and DE-FG03-98DP00211, LLNL contract W-7405-ENG-48, and NSF grants DMS-9722121 and DA21777-2.

W02

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Study of the energy transport in solid targets irradiated by intense ultrashort laser pulses using x-ray spectroscopy

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ABSTRACT

We will present a systematic study of the energy transport into a solid target irradiated by a high contrast fs-laser pulse. The experiments were done at the ATLAS Ti:Sapphire laser delivering 60-80mJ at the second harmonic with a pulse duration of 150fs. Frequency doubling guarantees a high contrast with the consequence of a steep density gradient at the target surface. Using an off-axis parabola we achieve peak intensities up to 5×10^{17} W/cm^2.

In order to investigate the energy transport into the solid target we utilized layered targets consisting of Al on a NaCl, or MgO on an Al substrate. By means of soft x-ray spectroscopy (using a transmission grating and a von Hamos crystal spectrometer) we determined the thickness of the heated layer for normal, and oblique incidence. The thickness is 250-500Å (normal incidence) and 1000-3000Å (oblique incidence, p-pol), respectively, depending on the ionization energy of the line under investigation. From the analysis of the Stark broadened spectra we conclude an electron density in excess of 10^{23} cm^{-3} and an electron temperature of a few 100eV.

In addition we measured the laser absorption. For normal incidence the absorption is 7% of the incident energy and the corresponding value for oblique incidence (45°, p-pol) is 49%. From the measured Bremsstrahlung emission and the low level of cold K_α emission, we follow that the fast electrons transport only a small fraction of the absorbed energy into the solid target.

We also addressed the possibility of lateral transport by measuring the source size of the emitting plasma.

Abstract submitted
for the 28th Annual Anomalous Absorption Conference
14-19 June 1988 Bar harbor, Maine

Observation of neutron spectrum from deuterated plastic irradiated by sub-picosecond ultra-intense laser.

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For understanding of the fundamental physics of the fast ignition, it is crucial to investigate the fast ion production in a high density plasma irradiated by a ultra-intense laser. The energy spectrum of the neutron produced in the deuterated target reflects the energy spectrum of fast deuteron accelerated in the interacting region. Due to high penetration ability of fast neutron, the neutron spectra directly bring out the information of the hot ions from the high density plasma. We have observed 10^6 of the DD neutron produced in a deuterated polystyrene $(C_8D_8)_x$ target irradiated by the 500-fs intense laser (up to 10^{19} W/cm^2). The fast neutron spectra were measured by multi-channel time-of-flight neutron spectrometer (MANDALA) at the GEKKO XII laser facility of Osaka University. The spectrometer has two sets of 421 channel detector arrays which was located at 90 and 125 degrees with respect to the irradiation axis. The mean energy of the neutron observed from 90 degree was up shifted by about 400 keV with the FWHM of about 1 MeV. This spectrum result from the fusion reaction created by highly accelerated ions. Thus it becomes possible to discuss the quantitative analysis of the fusion mechanism and ion acceleration. We report the details of the experiments and the quantitative analysis.

oral presentation is preferred .

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W04

28th Anomalous Absorption Conference
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High energy electrons produced during ultrafast laser-solid interaction

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A key issue in the field of laser-matter interaction using very intense subpicosecond optical pulses is the understanding of hot electron production. We have performed experiments [1] using an ultrashort pulse (100fs) laser focused on a solid target in very well controlled conditions, at moderate intensities ($I\lambda^2 \sim 2\ 10^{16}$ Wμm^2/cm^2). The distribution of the electrons flowing inward and outward of the target was measured for different initial electron density scale lengths. We found an isotropic distribution of energetic electrons going outward with an energy much larger than that predicted by a simple model of resonance absorption.
To understand the experimental results, we have used EMI2D a two-dimensional fully relativistic particle-in-cell code (PIC) to perform simulations of our experimental conditions. These simulations show that the interaction remains mainly one-dimensional for our range of intensities and pulse duration. Accordingly, we have used the 1-D EUTERPE code [2,3] to study more systematically the shape of the electron distribution for different density scale lengths. To compare with the experiment, we have post-processed the electron distribution obtained from the PIC code with a Monte Carlo electron transport model to calculate the Kα emission and the back-scattered electron flux. Modeling results will be presented and compared to experiments.

[1] S. Bastiani *et al*, Phys. Rev. E **56**, 7179 (1997).
[2] G. Bonnaud Laser Part. Beams **9**, 339 (1991)
[3] LLE Review **58**, 76 (1994).

Magnetic Field Generation in Short Pulse Laser-Plasma Interactions

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The energy from a short pulse intense laser interacting with a dense plasma is deposited in energetic electrons. The subsequent flow of these causes an induced electric field and a cold return current. Cancellation of the total current is however incomplete, and this paper discusses the role of the collisional skin depth, the collisionless skin depth, the anomalous skin depth, and lastly the skin depth associated with the development of lower hybrid turbulence in determining the resultant magnetic field. The effect of this field on pinching of the laser induced channel and on the transport of energy will be discussed.

Oral session preferred

Magnetic Field Collimation of Fast Electrons in Solid Targets

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March 12, 1998

Experimental and theoretical evidence for the formation of collimated fast electron jets in plastic and aluminium targets by picosecond, 1 μm wavelength, 10^{19} Wcm^{-2} laser pulses is presented. These results are of great importance for the fast igniter scheme. Laser probing showed plasmas, with diameters less than that of the laser spot, formed on the rear of solid targets, a few ps after irradiation by 10–30 J, 1 ps, 1 μm wavelength, p-polarised laser pulses focussed to spot diameters of 12–20 μm, giving intensities of 10^{18}–2×10^{19} Wcm^{-2}. 140-250 μm thick deuterated plastic and 50-125 μm thick aluminium targets were used. These experiments have been modelled with a Fokker-Planck hybrid code. The fast electrons are represented by a Fokker-Planck equation, including drag, angular scattering, electric and magnetic fields. The background is represented by $\mathbf{E} = \eta \mathbf{j}_b$, where η is the resistivity and $\mathbf{j}_b$ the background current density. The displacement current is neglected and the field equations are solved in r-z geometry. The fast electron propagation is initially limited by an electric field. This leads to strong ohmic heating lowering the resistivity and allowing the fast electrons to propagate further. A low resistivity channel is thus formed with a self generated magnetic field around the edge which acts to collimate the fast electrons. The reflective boundary at the rear surface leads to the formation of a magnetic field which focuses fast electrons on to it. The flux of fast electrons striking the rear surface is found to be readily capable of forming a plasma with a radius in excellent agreement with the experimental results. These results are not produced if the magnetic field in the code is switched off. This confirms that fast electrons are collimated in the target by a self-generated magnetic field.

1998 Anomalous Absorption Conference
Bar Harbor, Maine
June 14-19, 1998

Abstract

Long Wavelength Hosing

K-C. Tzeng, R. G. Hemker, B. J. Duda, and W. B. Mori

Departments of Electrical Engineering and Physics
University of California, Los Angeles

Using a fully explicit particle-in-cell model we have found over a wide parameter space that the eventual nonlinear state of a short-pulse laser propagating in a plasma is a long wavelength hosing instability. Previous theoretical analyses have predicted a hosing instability for which a laser with a finite spot size is modulated at a wavelength $2\pi c/\omega_p$. This instability is related to the forward Raman scattering instability of a plane wave. Using a variational principle approach, we have derived coupled equations for the laser's centroid and the plasma potential's centroid. These equations predict the usual hosing as well a long wavelength regime of hosing. This instability is related to the relativistic self-phase modulational instability. We will present results from numerous simulations and show the consequences of this long wavelength hosing instability. Implications to current and recent experiments will also be given.

This work is supported by DOE grant numbers DE-FG03-92ER40727 and DE-FG03-98DP00211, LLNL contract W-7405-ENG-48, and NSF grants DMS-9722121 and DA21777-2.

ORAL SESSION II

T. Johnston, Chair

Wednesday, 17 June 1998

28th Annual Anomalous Absorption Conference 14-19 June 1998

Laser penetration in overdense plasmas at relativistic intensities

J.Fuchs[1,2], J.C.Adam[3], F.Amiranoff[2], S.D.Baton[2], N. Blanchot[4], P.Gallant[1], L.Gremillet[2], A.Héron[3], J.C.Kieffer[1], G.Laval[3], G.Malka[4], J.L.Miquel[4], P.Mora[3], H.Pépin[1], and C.Rousseaux[4]

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3. Centre de Physique Théorique, CNRS, Ecole Polytechnique, Palaiseau, France

4. Commissariat à l'Energie Atomique, Limeil-Valenton, France

Propagation of a high-contrast subpicosecond (300-600 fs) relativistic ($I\lambda^2$ up to $2*10^{19}$ W.cm^{-2}.μm^2) laser pulse through thick preformed overdense plasmas and thin and initially solid foils is studied. Transmission values up to 10% are measured in plasmas with initial peak densities above $10*n_c$. The strong intensity threshold observed for the transmitted energy is correlated with clear modifications of the transmitted and reflected spectra, electron generation and beam imaging. The physical mechanisms involved in overdense propagation prove to depend strongly on the layer thickness. 1D analytical calculations suggest the occurrence of hole boring in thick preformed plasmas. For thin solid foils, 2D Cartesian particle-in-cell (PIC) simulations that meet the experimental results suggest specific rapid heating, plasma expansion and density decrease to relativistically transmissive conditions during the pulse.

ORAL PRESENTATION

W09

Ionization Induced Scattering of Short Intense Laser Pulses

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University of Maryland, College Park, MD 20742

Intense laser pulses propagating in gases undergoing inonization are subject to a scattering instability due to the dependence of the ionization rate on the laser electric field. The growth length of the instability scales inversely with the gas density and is on the order of a fraction of a centimeter for helium at 50 torr pressure. The instability is convective and growth is limited for a pulse of finite extent by propagation out of the unstable region. The most unstable perturbations scatter at an angle to the direction of propagation of the main laser pulse such that the transverse wavenumber roughly matches the plasma wavenumber. In the nonlinear regime the scattering instability saturates at a level that gives rise to full modulation of both the plasma density and laser pulse amplitude.

† Also Department of Physics

NIF Power Balance

Ogden S. Jones, D. Ralph Speck, John T. Hunt, Steven W. Haan, and Larry J. Suter

The ICF ignition targets require careful balancing of the power amongst the 192 beams that irradiate them. NIF is designed to provide 8% rms power balance for the baseline indirect drive and direct drive targets. Power imbalance is due both to repeatable and shot-to-shot differences among beams. Repeatable differences in beam performance are due to unavoidable differences in transmission, gain, and frequency conversion efficiency of the components that make up each beam. They are compensated for in two ways. The input pulse shape for each set of four beams ("quad") is adjusted to give each quad the same output pulse shape. Differences among beams within a quad are compensated for by adjusting the input energy to each beam. Shot-to-shot differences are caused by jitter in the optical pulse generation (OPG) system output, the amplifier gains, and the frequency converter efficiencies.

We analyzed the laser performance using the BTGAIN code, which solves for either the input or the output pulse shape for a chain of active and passive laser components, given the pulse shape at the other end of the system. This model uses Frantz-Nodvic theory to account for amplifier saturation, and each component is assigned a transmission to model distributed losses. Frequency tripling efficiency is modeled with a patch to the code that includes deviations from the optimum phase matching angle to account for fabrication and alignment differences among the tripler assemblies. First, a 192-beam model was built, with each beam made up of components whose gain, transmission, or deviation from phase matching angle was randomly selected from a gaussian distribution representing component tolerances. Then a series of Monte Carlo calculations were performed to determine the optimum strategies for compensating for repeatable differences among beams and to determine the allocation of shot-to-shot errors among subsystems in order to meet the power balance requirement.

In addition, we used the three-dimensional view-factor radiation transport code, Gertie, in combination with Lasnex to study the effect on the target of the power imbalance history predicted by the laser model.

Prefer oral session

W011

A Parallelized Laser Ray Tracer for ICF3D

T.B. Kaiser, J. L. Milovich, M.K. Prasad and A.I. Shestakov

ICF3D is a parallel unstructured mesh 3D code being developed for ICF physics modeling. It consists of several packages: hydrodynamics, heat conduction and laser ray tracing and power deposition. Here, we will discuss details of the laser package. It consists of a user-specifiable beam source and ray casting able to handle propagation to and through an arbitrary 3D material. The integrator can be used in first (constant index of refraction in a cell) or second (linear variation of the index of refraction) order modes. The second order mode is needed to obtain the correct trajectories when gradients are not aligned with the coordinate directions. It is fully parallelized using MPI (message passing interface) and domain decomposition. To achieve load balance, rays are processed in chunks and delivered to the appropriate processors (PEs) as they cross the interprocessor boundaries. This procedure permits other processors to participate in the computation while successive chunks of rays are processed. We present results on scalability to large number of PEs. Calculations involving the coupling with other physics packages in MPP simulations will also be presented.

Additional Submission: Please insert this abstract in your abstract book in Wednesday's Oral Session Section. Please note that this oral paper will be given in place of the originally scheduled presentation entitled "A Parallelized Laser Ray Tracer for ICF3D."

Abstract submitted to the 28th Anomalous Absorption Conference

Polarization and Spectral Dispersion Smoothing: Effects on SBS, SRS, and filamentation*

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Recent work [1] has established that polarization smoothing (PS) is as effective as SSD in controlling filamentation for the bandwidths (<3Å at 1.06 μm) for which 1.06 μm light can be efficiently converted to 0.351 μm light. In this paper, we consider the benefits of these smoothing techniques for controlling stimulated Brillouin backscatter (SBS) [2] and stimulated Raman backscatter (SRS). Typical simulation volumes (60 μm × 60 μm × 350 μm) allow the gain exponents for SBS and SRS to be comparable to those calculated for Nova gasbag experiments with damping rates for acoustic and Langmuir waves consistent with the plasma parameters.

* Work performed under the auspices of the United States Department of Energy by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48.

1. E. Lefebvre, R. L. Berger, A. B. Langdon, B. J. MacGowan, J. E. Rothenberg, and E. A. Williams, "Reduction of laser self-focusing in plasma by polarization smoothing," *Phys. of Plasmas,* to be published (1998).
2. S. Huller, Ph. Mounaix, and V. T. Tikhonchuk, "SBS reflectivity from spatially smoothed laser beams: random phase plates versus polarization smoothing," submitted to *Phys. of Plasmas,* Dec. 1997.

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In a dense plasma, the Coulomb energy between charged particles may be comparable to or greater than the kinetic energy associated with thermal motion. This leads to correlation between particles and in particular to structure in the relative average spatial positions of ions. This can have a profound effect on the bulk properties of plasma such as thermal and electrical resistivity and compressibility. Thus the study of such structure is of fundamental importance to plasma physics. As in a solid crystal, we can gain understanding of the internal arrangement of the particles by studying the manner in which the plasma scatters X-rays. We report on recent experiments which have attempted to measure the X-ray scattering cross-sections for dense plasmas. The plasmas have been created, either by irradiating a thin foil with soft X-rays from a laser plasma, or by direct laser driven shock compression of the foil. In both cases line radiation from a further laser plasma has been used to create a bright source of scattering X-rays. Single photon detection of the scattered X-rays with CCD detectors and monitoring of the brightness of the source allowed cross sections to be measured.

W013

The Omega Charged-Particle Spectrometer: Initial Results

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J. Soures, J. Knauer, J. Law, UR/LLE
T. Phillips, C. Sangster, M. Cable, T. Bernat, LLNL
J. Schnittman, Harvard University

Recent work has resulted in the first spectroscopic measurements of energetic charged particles on Omega. Individual line profiles of charged fusion products have been obtained, and include D-^{3}He protons (14.7 MeV) and D-^{3}He alphas (3.6 MeV); D-T alphas (3.5 MeV); and D-D protons (3.0 MeV) and D-D tritons (1.0 MeV). Knockon tritons and deuterons have also been observed and quantified. From these different particle measurments it has been possible to determine fusion yields, ion temperatures, fuel and ablator ρRs, anomalous accelerations, and implosions asymmetries. In addition, surprising and copious fluxes of energetic ablator protons and ablator ions have been observed from ~ 100 keV to 1.2 MeV. In particular, sharply-defined lines of energetic ablator protons are detected. When they occur, they have strong intensities at about 400 keV, with separations between adjacent lines of about 20 keV. The endpoint of the ablator protons is ~ 500 keV, suggesting that the capsule is charging to ~ 1/2 MV.

[a]Also Visiting Senior Scientist, UR/LLE. This work is supported in part by LLE (subcontract P0410025G), LLNL (subcontract B313975), and DOE (subcontract DE-PS03-97SF21293).

BANQUET

D. Bradley, Chair

Wednesday, 17 June 1998

Acadia's Rocky Shore Museum

Guest Speaker: M. Furnari

ORAL SESSION I

R. McCrory, Chair

Thursday, 18 June 1998

Late-Time Evolution of Broad-Bandwidth, Laser-Imposed Nonuniformities in Accelerated Foils

D. D. Meyerhofer, T. R. Boehly, D. K. Bradley, T. Collins, J. A. Delettrez,
V. N. Goncharov, J. P. Knauer, R. P. J. Town, and V. A. Smalyuk

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D. Oron, Y. Azebro, and D. Shvarts

Physics Department, Nuclear Research Center
Negev, Beer-Sheva, Israel

The late-time evolution of broad-bandwidth nonuniformities is studied in planar-foil experiments on the OMEGA laser system. Five beams with ~600-μm-diam uniform region accelerate 20-μm-thick CH foils at an average intensity of 2×10^{14} W/cm^2 in a 3-ns square pulse. Through-foil x-ray radiography is used to measure the temporal evolution of the target nonuniformity. The x rays from a uranium backlighter pass through an Al blast shield, the target, and are imaged with an x-ray framing camera. The imaging system has been fully characterized, the various noise sources are well understood, and a Weiner filter has been constructed. The nonuniformity associated with laser imprinting is amplified by the Rayleigh–Taylor instability during the acceleration of the target. Through the use of low-amplitude, imposed single-mode perturbations, the growth of the broad-bandwidth nonuniformity is found to be similar to the experimentally observed and numerically predicted growth of a single mode. At late times collective saturation is observed at levels similar to Haan's prediction.[1] The maximum of the nonuniformity spectrum moves toward longer wavelength in time as expected.

Prefer oral session.

[1]S.W. Haan, Phys. Rev. A **39**, 5812 (1989).

This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

Initial Studies of Hydrodynamics of Cylindrical Implosions using Direct Drive on the OMEGA Laser

Cris W. Barnes, David L. Tubbs, Peter L. Gobby, Nelson M. Hoffman,
Ken A. Klare, John A. Oertel, Robert G. Watt
Los Alamos National Laboratory
Thomas R. Boehly, David Bradley, James P. Knauer
Laboratory for Laser Energetics, University of Rochester

Cylindrical implosions for hydrodynamic studies using direct drive have been designed and fielded on the OMEGA laser at the Laboratory for Laser Energetics. Fifty beams using distributed phase plates (DPPs) and smoothing by spectral dispersion (SSD, with 1.25 by 1.75 Å bandwidth) illuminate a 900 μm outer diameter, 2250 μm long right-cylindrical shell of polystyrene that is 20 μm thick, including a 4 μm thick dichloropolystyrene marker layer. (The inner diameter of this ablator is exactly twice the size of previous cylindrical implosions experiments done using indirect drive on Nova[1].) The illumination pattern on the cylinder places approximately half the total beam energy uniformly on a 500 μm long region. The implosions are driven with a 2.5 nsec linear ramp pulse delivering 19 kJ with $\sim$ 8.5% RMS energy balance. The implosions have been radiographed both axially and transversely using 5 or 8 of the remaining beams (also with DPPs and SSD) that illuminate thin (6 μm thick) titanium backlighter foils. Marker layers of two lengths (500 μm and 250 μm) were tried to evaluate effects of parallax and matching the hydrodynamic motion to the illumination pattern. The short marker layers did not show significantly improved images from reduced parallax effects, while they suffered from the hydrodynamic mismatch to the laser drive along the length. The long-marker-layer targets provided axial images of very symmetric implosions: only a few percent mode asymmetry for observed convergence ratios of the marker of up to $\sim$ 7. The implosion trajectories (radius vs time) are cleanly determined and show sensitivity to the as-shot pulse shapes of the drive. Rayleigh-Taylor growth of 1.5 μm initial amplitude m=28 machined perturbations are resolved; preliminary results show growth factors of 9 at a convergence ratio of 1.9. Transverse images of the self-emission, including from the buried chlorinated marker layer, provided an interesting cylindrical analogue to spherical "burnthrough" experiments.[2] This initial campaign effectively defined a successful operational space for performing convergent hydrodynamic experiments using direct drive on OMEGA. The next round of experiments is planned in July, 1998 and will concentrate on amplitude and wavelength variations of the Rayleigh-Taylor growth.

This work supported by DOE Contract W-7405-ENG-36.

[1] W. W. Hsing, C. W. Barnes, J. B. Beck, N. Hoffman, D. Galmiche, A. Richard, J. Edwards, P. Graham, S. Rothman, and B. Thomas, Phys. Plasmas 4, 1832 (1997).
[2] J. Delettrez, D. K. Bradley, and C. P. Verdon, Phys. Plasmas 1, 2342 (1994).

Mix experiments on the 60 beam OMEGA laser system using Smoothing by Spectral Dispersion (SSD)

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Abstract

We present the results of experiments designed to study hydrodynamic instability growth in spherical targets imploded by the 30 kJ OMEGA laser system. Instability growth during the acceleration phase of the implosion is diagnosed using the so-called burnthrough technique, in which time resolved x-ray spectroscopy is used to detect the onset of characteristic line emission from a signature layer buried under a plastic ablator. This technique has been shown[1] to be a sensitive indicator of instability growth and hence, of incident drive nonuniformity. Buried dopant layers can also be used to diagnose conditions inside the shell during the deceleration phase of the implosion[2]. We will show data from targets imploded by both unsmoothed laser beams, and those smoothed using distributed phase plates (DPP's) coupled with 2-dimensional smoothing by spectral dispersion (2D-SSD). The results will be compared to both hydrocode simulations and one-dimensional mix models.

1. D. K. Bradley, J. A. Delettrez, and C. P. Verdon, Phys. Rev. Lett., 68, 2774 (1992); J. Delettrez, D. K. Bradley, and C. P. Verdon, Phys. Plasmas 1, 2342 (1994).
2. D. K. Bradley *et al*, to be published, Phys. Plasmas (1998)

TH04

Convergent Rayleigh-Taylor Experiments on the Nova Laser

C. Cherfils[1], D. Galmiche[1], A. Richard[1], S.G. Glendinning[2], S. Haan[2], B.A. Remington[2], R. Wallace[2], V.N. Goncharov[3]

[1]CEA-DRIF, Centre de Bruyères-le-Châtel, 91680 Bruyères-le-Châtel, France
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In the frame of a CEA/DOE collaboration, ablation front Rayleigh-Taylor experiments in spherically convergent geometry have been done on the Nova laser [1]. Capsule is mounted on side of a hohlraum, with half the sphere interior to the hohlraum. The hemisphere situated within has a 70μm wavelength, 2 μm amplitude, 2D sinusoidal ripple imposed on it. Perturbation growth is diagnosed by face-on radiography.
RT growth and saturation obtained in experimental data are correctly reproduced in numerical simulations of the radiographs. Modellings of RT growth during the linear stage are tested against spatial amplitude extracted from FCI2 simulations. Good agreement is found with a new model [2] predicting the ablative hydrodynamic instabilities of a spherical converging shell.
The ablation front convergence ratio is close to two. Another set of experiments is planned on Nova with enhanced convergence effect.

[1] Proceedings of the Sixth International Workshop on the Physics of Compressible Turbulent Mixing, 1997, p.116-121 and p.173-178.
[2] R. Betti, V.N. Goncharov *et al.*, Proceedings of the Thirteenth International Conference on the Laser Interactions and Related Plasma Phenomena, 1997, p.294.

Computations of Gold Coated Plastic Laser Accelerated Targets

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Denis Colombant, & Andrew J. Schmitt
Plasma Physics Division, Naval Research Laboratory, Washington, DC

John H. Gardner, & Lee Phillips
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Marcel Klapisch
ARTEP, INC, Columbia, MD

We present results from one-dimensional and two-dimensional computations of thick plastic laser-accelerated targets that are coated on the laser-irradiated side with a thin (1000 Å) layer of gold. These simulations are in support of ongoing low-intensity (5×10^{12} W/cm^2) Nike (KrF) 'foot pulse' experiments.[1] This problem is relevant to a recently-proposed pellet design,[2] and is also intrinsically interesting as a clean radiation transport / hydrodynamics code benchmark. We are using FAST for this problem.[3] All calculations are run in non-LTE, using NRL STA opacities. Results from the gold-coated plastic [CH] target runs show a dramatic difference when compared with otherwise identical uncoated plastic. In cases with no gold overcoat, the evolving plastic scalelengths are on the order of a few tens of microns, but when the gold coating is present, the dynamics are very different. As the laser-illuminated gold layer is heated, it generates x-rays that preheat the plastic. Within a few hundreds of picoseconds, the gold separates from the bulk of the target and accelerates towards the laser. A long density scalelength fills the region between the ablating gold and the solid target. As the gold layer disperses, more laser light reaches this long-density region, and in the effectively rising laser pulse, RPS (Radiating Plasma Structures)[4] are observed in the calculations. Comparison with the experimentally observed[1] gold and plastic emission regions will be discussed.

Work supported by USDoE and USONR.

[1] S.P.Obenschain, private communication.
[2] S.E.Bodner *et al., Phys.Plasmas,* (May, 1998).
[3] J.H.Gardner *et al., Phys.Plasmas,* (May, 1998).
[4] J.P.Dahlburg *et al., JQSRT,* **54**, 113 (1995).

Oral presentation preferred.

TH06

Recent Studies in the Nonlinear Evolution of Rayleigh-Taylor and Richtmyer-Meshkov Instability.

D. Shvarts [1], D. Oron [1,2], U. Alon [3], Y. Yedvab [1,2]

1. Physics department, Nuclear Research Center – Negev, Beer-Sheva, Israel.
2. Physics department, Ben-Gurion University, Beer-Sheva, Israel.
3. Physics department, Princeton University, Princeton, N. J.

A statistical mechanics model for the bubble and spike front evolution from single and multi-mode initial perturbation under the conditions of the RT and RM instabilities was developed over the last few years [1,2]. The basic elements of the model, the singe-mode bubble and spike evolution and the two-bubble competition process, have been recently verified in low-Mach number shock tube experiments for a variety of initial conditions and Atwood numbers [3].

Recently, the model has been extended to include additional scale-lengths in the problem, such as the ablation velocity in an ICF application [4], and the radius of curvature in nonplanar geometries [5]. The changes in the classical power-laws of the late time evolution of the bubble front of an ICF target due to the existence of these additional scale-lengths will be discussed.

[1] D. Shvarts, U. Alon, D. Ofer, R. L. McCrory, C. P. Verdon, Phys. Plasmas **2**, 2465 (1995).

[2] U. Alon, J. Hecht, D. Ofer, D. Shvarts, Phys. Rev. Lett. **74**, 534 (1995).

[3] O. Sadot, L. Erez, U. Alon, D. Oron, L. A. Levin, G. Erez, G. Ben-Dor, D. Shvarts, Phys. Rev. Lett. **80**, 1654 (1998)

[4] D. Oron, U. Alon, D. Shvarts, Phys. Plasmas **8** (May 1998).

[5] Y. Yedvab, U. Alon, D. Shvarts. D. Oron, *proceedings of the 6th IWPCTM, Marseilles, 1997,* Ed: G. Jourdan. L. Houas.

TH07

Equation of State Measureme
Hydrogen Isotopes up to 3

G. W. Collins, P. Celliers, L. B. Da Silv

K. S. Budil, R. Stewart, N. C. Holmes, M. Ross, . A. Hammel, J. D. Kilkenny,

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The Nova laser was used to shock-compress liquid deuterium and obtain measurements of density, pressure, temperature and reflectivity between 0.3 and 3 Mbar. Pressure-density measurements were obtained with time resolved radiography and show a rapid increase in density from 0.6 g/cc at .3 Mbar, to 1 g/cc at ~1 Mbar, reveal a much higher compressibility than predicted by Sesame. Temperatures, determined from optical emission of the shock front, are significantly lower than the standard Sesame tables predict. Reflectivity measurements of the deuterium shock front reveal the shock front becomes highly conducting between .3 and .6 Mbar, right where the fluid is becoming highly compressible. The combined pressure, density, temperature, and reflectivity data strongly suggest that deuterium transitions from a molecular insulating fluid to an atomic conducting fluid between .3 and 1 Mbar. Moreover, more energy is removed during the transition than previously thought, giving rise to the measured low temperatures and high compressibility.

Oral presentation

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract no. W-7405-Eng-48.

ORAL SESSION II

R. P. Drake, Chair

Thursday, 18 June 1998

NEW BEAM SMOOTHING EXPERIMENTS AT THE NOVA LASER*

B.J. MacGOWAN, R.L. Berger, B.I. Cohen, C.D. Decker, S. Dixit, C. Geddes, S.H. Glenzer, D.E. Hinkel, R.K. Kirkwood, A.B. Langdon, B.F. Lasinski, E. Lefebvre†, L. Lours, J.D. Moody, J.E. Rothenberg, C. Rousseaux†, L.J. Suter, C.H. Still, E.A. Williams

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†*Centre D'Etudes de Bruyere le Chatel, France*

In recent years Nova experiments and modeling in the area of laser plasma interactions (SBS and SRS backscatter, beam propagation) and beam smoothing have focused on plasma and laser beam conditions representative of the National Ignition Facility (NIF) point design hohlraum. The point design hohlraum is a 300 eV radiation temperature hohlraum that will contain a low-Z plasma at about 10% of critical density for 3ω light. The f/8 laser beams were expected to have a peak irradiance of 2 10^{15} Wcm^{-2} and be smoothed by a random phase plate (RPP) and a small amount of smoothing by spectral dispersion (SSD). Experiments have shown that with moderate amounts of beam smoothing, scattered light losses can be reduced to a level where they should not seriously impact the energetics or symmetry in NIF ignition hohlraums.

As part of an integrated plan for attainment of ignition on NIF we are now carrying out studies to evaluate the effectiveness of beam smoothing at reducing backscattered light (SRS and SBS) as we depart from the point design hohlraum conditions. These studies are intended to allow us more latitude in choosing the eventual design with which we will attempt to ignite some time after 2006. As well as studying scaling to the higher densities and higher laser intensities expected in 350eV hohlraums we are also exploring new implementations of laser beam smoothing more representative of what will be possible on NIF in both its baseline design and potential modifications. We have performed experiments with Kinoform Phase plates (KPPs) and SSD using a high frequency modulator (17 GHz) capable of generating bandwidths up to 5Å at 1ω (in excess of that presently planned for NIF). NIF will use a higher frequency modulator than used for previous Nova experiments in order to reduce the beam dispersion required for SSD. The lower dispersion will allow laser propagation through spatial filter pinholes and the hohlraum entrance hole without clipping, but has the potential drawback that smoothing at large spatial scales does not occur. We are also testing Polarization Smoothing through incorporating wedged KDP plates in the final optics which split the beam into two polarization components and displace them such that they add incoherently in the target plane, smoothing the intensity distribution. These techniques should allow us to suppress filamentation of hotspots and, in the case of polarization smoothing, reduce the intensity in hot spots.

Filamentation, SBS and SRS have been calculated in 3D with the use of the F3D code which solves the nonlinear hydrodynamic equations coupled to a set of paraxial equations to describe the incident, SBS and SRS reflected light. In the calculations we find that 2 - 5 Å of bandwidth, or application of polarization smoothing are sufficient to reduce filamentation and backscattering. If both smoothing schemes are used, the distribution of intensities can be held to the KPP vacuum value (i.e. the plasma filamentation response that would increase hotspot intensities is suppressed). Our experiments will be compared to these predictions together with those for more stressful plasma and laser conditions.

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Prefer oral session

TH09

Generation of large levels of ion acoustic waves by combined spatial and temporal beam smoothing

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Abstract

It is shown that ion acoustic waves can be resonantly driven by the beating of the different Fourier components of a laser beam that contains some temporal bandwidth, in addition to spatial smoothing. The spectral density $|\delta n_{\vec{k}}|^2$ and the level of density fluctuations $\delta n/n$ are both derived analytically as a function of the laser bandwidth. These fluctuations are found to be directed in a direction perpendicular to the propagation of the laser beam. Their level $\delta n/n$ can become very large (tens of %) on a time scale of the order of tens of picoseconds. These analytical results are checked by numerical simulation using the hydro-code "KOLIBRI"[1,2] .

The potential nonlinear mechanisms for spreading the k-spectrum of $\delta n_{\vec{k}}$ from the transverse direction into the longitudinal direction are examined. The effect of these fluctuations on SBS reflectivity is investigated.

[1] S. Hüller, Ph.Mounaix, and D. Pesme, Phys. Scr. **T63**, 151 (1996).

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Observation of Resonant Energy Transfer Between Identical-Frequency Laser Beams

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We report enhanced transmission of a laser beam when crossed with a higher-intensity, identical-frequency beam in an exploding Be foil plasma. This enhancement was maximized when the plasma flow velocity was near the ion sound speed (Mach 1). The time history of the enhancement and the dependence on the flow velocity indicate that this effect is due to energy transfer between the beams via a resonant ion wave with zero frequency in the laboratory frame. Linear gains of ~1.6 have been observed when the beams intersect in a region with a Mach 1 plasma flow.

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Oral session requested

TH011

Pushing the Limits: Strongly-Driven Laser Plasma Coupling

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An improved understanding of strongly-driven laser plasma coupling is important for optimal use of the National Ignition Facility for both inertial fusion and for a variety of advanced applications. Such applications range from high energy x-ray sources and high temperature hohlraums to fast ignition and laser radiography. We discuss a novel model for the scaling of strongly-driven stimulated Brillouin and Raman scattering. This model postulates an intensity - dependent correlation length associated with spatial incoherence due to filamentation and stimulated forward scattering. We first motivate the model and then relate it to a variety of experiments. Particular attention is paid to high temperature hohlraum experiments, which exhibited low to modest stimulated Brillouin scattering even though this instability was strongly driven.

Return-Current Electrons and Their Generation of Electron Plasma Waves

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Important new information on electron plasma waves (EPW) is being obtained by Thomson scattering of short-wavelength probes from low-density plasma.[1] EPW's have been seen moving in the direction expected from stimulated Raman scattering (SRS) and called "primary." EPW's are also seen moving in the reverse direction and called "secondary." These secondary EPW's are interpreted as due to saturation of SRS by the Langmuir decay instability (LDI). The authors in Ref. 1 have noted several difficulties in this interpretation. These difficulties include a much larger amplitude of the primary EPW's than expected from convective gain calculations; yet the level is too low to correspond to the theoretical LDI threshold. At the lowest plasma densities, the threshold is so high that LDI, which is seen, should not occur at all. The observed ratio of secondary to primary EPW fluctuation amplitude is also far below the expected level of about 0.5. There is also the difficulty that the EPW's seem to be generated partway on the density slope, rather than at the peak.[2] Some but not all of these discrepancies may be reduced by considering generation of the SRS in speckles.

Alternative explanations should be considered. Implosion experiments on OMEGA suggest that a surprisingly high positive electrostatic potential level may be created in laser-produced plasma.[3] Under these circumstances, return currents of electrons from the walls must exist and, depending on the geometry, can be rather beamlike as they enter the plasma. These return currents arise from breakdown triggered by the high-intensity interaction beam. For the low-density plasmas used in Ref. 1, these "beams" can transit the plasma with only minimal dissipation. Those entering the plasma can create "primary" EPW's, and those emerging will create "secondary" EPW's. We will discuss the extent to which such a model could fit the observations in Ref. 1 and many earlier experiments.

Prefer oral session.

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This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

TH013

Twenty-Eighth Annual Anomalous Absorption Conference
Bar Harbor, Maine
14-19 June, 1998

The Two Plasmon Decay Instability with Overlapping Structured Laser Beams in Direct Drive Laser Fusion Targets

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Two plasmon Decay ($2\omega_{pe}$), the decay of an electromagnetic wave into two electron plasma waves[1], is a potentially dangerous parametric instability in the context of direct drive laser fusion[2] and high radiation temperature hohlraums. This high frequency instability occurs near the quarter critical density, has a low threshold and a large growth rate [3], so that unacceptable levels of deleterious hot electrons could be created because of it, which would preheat the fuel. This instability has been well analyzed when there is but one pump wave which is monochromatic and spatially uniform[4]. Here we develop the theory of $2\omega_{pe}$ in the presence of overlapping laser beams each of which may have spatial and temporal structure. We calculate the convective amplification of $2\omega_{pe}$ in the presence of pump amplitude and phase modulations and ion acoustic wave (IAW) fluctuations, followed by an analysis of the impact of overlapping laser beams on this instability. The effects of angular beam spread, or (f/#), beam crossing angles, and the degree of speckle pattern overlap in the interaction region are examined.

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PREFER ORAL SESSION

REVIEW TALK

R. Short, Chair

Thursday, 18 June 1998

Behavior and Implications of Time Dependent Filamentation in ICF

A. J. Schmitt

Abstract submitted for the 28th Annual Anomalous Absorption Conference

Behavior and Implications of Time Dependent Filamentation in ICF†*

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Abstract

Laser light filamentation and its resulting temporal evolution fundamentally changes the conditions of the laser-plasma interaction. We review results of numerical simulations of filamentation and temporal evolution in ICF-relevant plasmas[1]. Typically, the evolution of filamentation results in long term unsteady behavior. Also, the interaction impresses temporal and spatial incoherence upon time-independent incident laser light. Increasing the interaction strength produces more redshift and broadening of the transmitted light spectrum. Analysis of the transmitted light reveals that stimulated Brillouin forward scattering (SBFS) contributes to the generation of the observed temporal incoherence. At higher intensities, the induced incoherence can be comparable to the incoherence typical in temporal beam smoothing (TBS) methods, such as ISI or SSD. However, under comparable interaction conditions, TBS beams will undergo far less angular and spectral spreading and far less SBFS than non-temporally smoothed beams.

Experimental results in this field[2] will also be reviewed and discussed in the context of this and other[3] simulation results. The implications and effects of filamentation and SBFS behavior on the physics of laser-plasma interactions will be addressed.

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†*Work done in collaboration with Bedros B. Afeyan, who worked under the auspices of the U.S. DoE by LLNL under contract No. W-7405-ENG-48.*
**Supported by U.S. Department of Energy*

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MIXED POSTER SESSION

Thursday, 18 June 1998

Twenty–Eighth Annual Anomalous Absorption Conference
Bar Harbor, Maine
14-19 June, 1998

New Phase Space Techniques for Beam Propagation in Inhomogeneous, Anisotropic and Nonlinear Media

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New theoretical formulations and numerical implementations of beam propagation in inhomogeneous, anisotropic and nonlinear media will be presented. The general idea is to use successively more detailed descriptions of the fields in their phase space. This way, from rays to full waves can be treated in various level of asymptotic approximation as warranted at any given patch in phase space. These versatile and embedded sets of approximations rely on phase space distribution functions such as the Wigner function and its generalizations, and their approximate evolution. Rays, Gaussian wavepackets, and adaptive wavelet ensembles can all be used to form a continuity of approximate representations that span phase space with any prescribed local accuracy. The connections between these methods and various well known approximate implementations of path integrals will also be given.
We will compare the performance of these techniques as implemented in new phase space evolution codes with those of pseudospectral SOFTSTEP codes for both linear, and nonlinear wave propagation problems in inhomogeneous plasmas.

*This work is performed under the auspicies of the U. S. Department of Energy by the Lawrence Livermore National Laboratory under contract number W–7405–ENG–48.

PREFER POSTER SESSION

THP2

Abstract submitted for the 28th Annual Anomalous Absorption Conference

Simulations of tungsten, tungsten-coated and tungsten-doped targets at low KrF laser intensities

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Abstract

High-Z coatings can be used to create X-rays to preheat the ablator which have the effect of reducing the laser imprint and the R-T instability. Targets with tungsten included on the surface or mixed with CH have been recently irradiated using Nike at intensities of a few 10^{12} W/cm^2, typical of the foot of a laser fusion pulse.

The present simulations in 1D have been carried out to provide an interpretation of these experiments and to validate the code for radiation-preheated target designs[1]. All computations presented have been run in non-LTE.

Low-resolution X-ray spectra obtained from on-line computations are compared to the time-integrated experimental spectra below 500 eV. Agreements as well as differences between computations and experiments will be presented and discussed.

Work supported by USDOE

1.S.E.Bodner et al, Phys. Plasmas (May 1998)

+ SAIC, McLean,Va.
* ARTEP Inc., Columbia, Md.
# Space Science Division, Naval Research Laboratory

Abstract submitted for the 28th Annual Anomalous Absorption Conference

Observations of Time-Dependent Symmetry in Tetrahedral Hohlraums at Omega using the Reemission Technique

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Spherical hohlraums with four laser entrance holes arranged in a tetrahedral pattern allow the possiblility of achieving a high degree of drive symmetry on a capsule in the center. In this presentation, we give results from a recent series of experiments performed at the Omega laser system at the Laboratory for Laser Energetics using reemission capsules in "tetrahedral" hohlraums for measurements of drive symmetry. All 60 Omega beams illuminated the tetrahedral hohlraum with approximately 22 kJ of energy. The reemission technique of drive symmetry measurement will be described. Viewfactor code calculations will be presented which give the expected levels of symmetry for the specific hohlraums used in this experiment. Gated x-ray imaging measurements of a bismuth coated reemission sphere centered in a tetrahedral hohlraum are shown. The data is interpreted using modal analysis to infer the dominant drive symmetry modes present in the hohlraum. The results show a high level of drive symmetry and are in qualitative agreement with symmetry results inferred from implosions of deuterium filled plastic shells, which were also observed in this series of experiments. Future plans for tetrahedral hohlraums and the utility of the reemission technique will be discussed.

[X] Poster Presentation Preferred

THP4

MESOSCALE ANALYSIS OF NONLINEAR SRS IN LARGE SYSTEMS

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ABSTRACT

The large range of space and time scales necessary for the microscopic modeling of the nonlinear saturation of SRS (and other parametric instabilities) in macroscopic systems of NIF relevance may be beyond the capacity of proposed massively parallel computers. A mesoscale modeling method is being studied which averages over the "microscopic" scales of the secondary Langmuir turbulence excited in the nonlinear saturation of SRS. Mean field equations, which evolve on the intermediate scales, are derived for the envelopes of the three primary waves involved in SRS and for the mean modification of the density profile. The coupling to the underlying turbulent fluctuations appears as nonlinear effective damping and frequency detuning coefficients in the mean Langmuir wave envelope equation and as a mean Langmuir fluctuation energy density in the ponderomotive pressure driving the mean density modification. The turbulent fluctuations are driven by the local mean primary Langmuir wave field at the mean modified local density; the latter two parameters determine the turbulence coefficients. Estimates for the contribution to the mean reflectivity from the fluctuations of the scattered light about its mean can be related to resonance correlation properties of the Langmuir fluctuations. Using simple scaling law forms for the nonlinear coefficients the predictions of the mesoscale modeling will be compared to fully turbulent 1D reduced model simulations.

* For POSTER presentation at the 28th Anomalous Absorption Conference, Bar Harbor, Maine, June 14-19, 1998
Research supported by the USDOE

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LLNL Nova laser irradiated gold disk experiments diagnosed with Thomson scattering compared to LASNEX simulations. **Kent Estabrook,[1] Siegfried Glenzer,[1] Christina A. Back,[1] W.Rozmus,[2] George B. Zimmerman,[1] John S. De Groot,[3] R.W.Lee,[1] Brian Wilson,[1] Brian MacGowan,[1] Hans Griem,[4] Judith A. Harte,[1] and David S. Bailey[1]** [1]*Lawrence Livermore National Laboratory,* [2]*U.Alberta and Institute for Laser Science and Applications(LLNL),* [3]*University of California at Davis and* [4]*U.Maryland, College Park.*

We use Thomson scattering to measure electron temperatures, ionization states and drift velocities from gold irradiated with a single 3.6KJ Nova beam at 64 degrees. We measure at a distance 500 microns normal from the disk. The blue heater is f/4 at 64 degrees. From the Thomson spectra we infer how flat-topped are the electron distributions. The heater turns off at 1.5 nsec and .75 nsec after that, calculated electron temperatures and ionization states are sensitive to the LASNEX atomic physics model, with a more detailed model in remarkably better experimental agreement. We also compare experimental and calculated x ray spectra.

Auspices U.S.D.O.E. by LLNL Contract W-7405-ENG-48

Abstract submitted to the 28th Anomalous Absorption Conference, Bar Harbor, Maine, June 14-19, 1998

poster please.

THP6

Shinethrough of Various Barrier-Layer Materials

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In inertial confinement fusion (ICF), hydrodynamic instabilities, in particular the Rayleigh–Taylor (RT) instability, seeded by laser nonuniformities can be a significant problem. Initial nonuniformities on the surface or within the volume of the pellet grow exponentially, leading to a turbulent mixing of the fuel with the pusher material. One source of initial nonuniformities comes from laser breakdown inside the pellet shell, which can occur if sufficient laser energy is transmitted through the outer boundary of the pellet ("shinethrough") to ionize regions within the bulk of the shell, creating nonuniform regions of high pressure and temperature. These regions subsequently provide the seed for the RT instability. The shinethrough can be mitigated by applying a layer of opaque material (a barrier layer) such as aluminum to the surface of the target. The opaque material forces the breakdown to occur at the surface of the target. Aluminum, however, does not have the required permeability to allow high-pressure cryogenic DT targets to be filled, nor is it compatible with cryogenic target preparation and diagnostics. We report on studies of the breakdown and transmission characteristics of potential barrier-layer materials as well as shell materials. The laser conditions are similar to those expected on OMEGA ($\tau = 1.4$ or 40 ps, $\lambda = 351$ nm, intensity up to 10^{12} W/cm^2). The pulse durations are consistent with the expected rise times of OMEGA pulses. The transition from linear to nonlinear absorption varies strongly among different clear dielectric polymers (possibly related to the density of electron orbitals). The breakdown mechanism was investigated for polystyrene and mylar targets, which were bombarded with electrons to induce a population of free electrons. No change was observed in the transmission. This suggests that the electron-avalanche model is not the dominant mechanism of absorption under these conditions. Other possibilities will be discussed.

Prefer poster session.

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Modeling Laser Driven Radiography

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High energy (> 1kJ), high intensity (~10^{21} W cm^{-2}), short pulse lasers may produce very bright beams of 2–8 MeV γ–rays with a source dimension of ~100 µm. Such beams can produce highly space and time resolved radiographs through thick, high-Z materials (e.g. 4 inches of lead). We present model calculations supporting this concept using monte-carlo electron/photon transport, PIC, and radiation-hydrodynamics codes to estimate brightness and beaming effects, to optimize laser and target parameters, and to analyze recent LLNL experiments.

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THP8

X-ray Emission Spectroscopy of Deeply Buried Tracer Layers as a Deep-Heating Diagnostic for Fast Ignitor Experiments

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The fast ignitor concept for inertial confinement fusion relies on hot electrons, produced by a short-pulse (> 0.5 ps), high intensity (~ 10^{20} W/cm^2) laser, to deposit their energy deeply into high (> solid) density plasmas and thereby heat the compressed fuel to ignition. In order to investigate aspects of this process, we have performed deep heating experiments with solid-density targets irradiated by 5-20 ps, 300-500 joule laser pulses focused to intensities in excess of 10^{19} W/cm^2. The targets consisted of Al-coated CH slabs overcoated with 5 - 20 μm CH, and H-like and He-like line emission was used to diagnose temperature and density in the deeply buried Al layer. The data show deep heating at near-solid densities with line emission durations less than 20 ps, and in some cases show unusual line ratios. We discuss the data and their interpretations.

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Ultra High Intensity Inverse Bremsstrahlung

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Collisional absorption and collisional fast electron generation with ultra high intensity laser pulses is studied. In the ultra high intensity regime the inverse bremsstrahlung process is one of the most important mechanism of the fast electron generation and of the laser energy absorption in a plasma [1], [2]. It can be viewed as a stochastic acceleration process due to the nonlinear Compton harmonic resonances induces by the ion Coulomb field [3]. The expression for energy exchange between ultra intense laser field and electrons due to the inverse bremsstrahlung is derived through the application of the Madey's theorem [4]. The result is obtained for circularly polarized as well as for linearly polarized laser wave. The absorption rate is calculated for instantaneous collisions (when the scattering time is much less than the period of the wave) and for remote collisions as function of the beam velocity, impact parameter, azimuthal angle and the wave polarization. A fully relativistic calculation of inverse bremsstrahlung for laser intensities more than 10^{18} W/cm^2 displays some interesting features, for example the so-called Marcuse effect or inverse bremsstrahlung stimulated emission decrease dramatically as a result of relativistic effect. The relation with the results obtained in other approximations is discussed.

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THP10

Modeling ICF Capsule Line Emission in 3 Dimensions

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Line emission from ICF implosions can be used to diagnose the temperature of the DT fuel and provides an indication of the distortion in the fuel-pusher interface. We have reported the results of models with two spatial dimensions in earlier papers. Rayleigh-Taylor instabilities are responsible for most of the distortion of the fuel-pusher interface, and they saturate differently in two and three dimensions. The models presented in this paper are the first attempt to carry out this modeling in three dimensions. The goal of this modeling is to assess the 3D effects on line emission, but at this stage much of the work consists of getting the necessary codes running in parallel. Preliminary models and reports on the computing requirements of these calculations will be presented.

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Numerical simulation of X-ray laser signal build-up using a Maxwell-Bloch description

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We present 2D numerical simulations of the build-up of spatial coherence in X-ray lasers, operating either in a single-pass or in a double-pass configuration. Paraxial Maxwell-Bloch theory is used to describe amplification of spontaneous emission of the X-UV radiation travelling along the plasma axis in both counter-propagating directions.

The electromagnetic field is taken into account through a bi-directional, paraxial, slowly-varying temporal and spatial envelope approximation. The geometry is two-dimensional with one transverse direction, and accordingly the field is assumed to be linearly polarized along the third direction. This choice is well suited to simulations of X-ray lasers using plane solid laser targets.

The polarisation vector P, which couples the evolution of excited states of the lasing ion to the evolution of the electromagnetic field, is calculated through an extended set of Bloch equations. The level degeneracies are explicitly taken into account. The contribution of the spontaneous emission noise is introduced through a stochastic source term with a randomly generated phase.

The space and time evolution of the plasma quantities required such as level populations, electron density, etc, are either provided by a hydrocode or modeled by analytic profiles.

The near-field and far-field intensity patterns and the complex degree of coherence are then calculated at the output plane of the amplifying medium and away from it. We have investigated the effect of doublepassing the amplified X-UV radiation with a curved mirror placed at some distance from one of the plasma ends.

THP12

Abstract submitted to the 28^{th} Anomalous Absorption Conference

PIC SIMULATIONS OF HOLE-BORING FOR FAST-IGNITOR APPLICATIONS.*

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We are using our electromagnetic PIC code, ZOHAR, to study hole-boring by ultra intense laser beams into overdense plasmas. In particular, we describe our recent work using particle tracking to delve more deeply into the physical mechanisms which are identified in these simulations.

Our simulation parameters are guided by experiments to study aspects of the fast ignitor fusion concept.[1] Both the ρr of the simulated plasma slabs and the time scale of the ZOHAR modeling are roughly comparable to present short pulse experiments with thin CH foils and high laser intensity. Absorption fractions are high and we verify the predicted scaling for $T_{\rm hot}$.[2] A narrow channel is formed accompanied by static magnetic fields which are as high as 10^9 G for simulations at 10^{21} W/cm^2 in a $50n_c$ plasma.

Particle tracking allows us to explore the nature of the currents that produce and interact with these large static magnetic fields. A given particle's orbit in this channel depends on both the large static magnetic fields and the laser fields. As particles move down the channel, they enter regions of weaker laser field due to the high absorption. A fraction of the particles in the channel at any given time are moving forward and continue to remain in the channel and thus constitute the current associated with this large static magnetic field. In contrast, the smaller return current on the outside of the channel does not consist of a continuous stream of electrons. The return current particles are defocused by the magnetic field and hence move away from the channel and the return current region.

Particle orbits at various stages of channel formation are being studied as part of our program to develop a more complete understanding of the hot electron generation as the short pulse, high intensity laser penetrates overdense plasma.

* Work performed under the auspices of the United States Department of Energy by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48.

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LA-UR-98-1575
Poster-Preferred

Simulation of Rayleigh-Taylor Growth in Experiments With Radiatively Driven Thin Planar Foils

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We have extended earlier computational and experimental studies[1] of Rayleigh-Taylor instability of thin planar copper foils radiatively driven in NOVA hohlraums. The foils were typically 18 μ thick with 45 μ wavelength drive-side surface perturbations of 0.5 μ amplitude. The foils were accelerated under a "P26" laser pulse yielding a peak radiation temperature of 190 eV after about 1.5 ns. The developing bubble-and-spike pattern in the foil was analyzed with a 6.7 keV backlighter, looking both parallel and perpendicular to the initial corrugations. Over 3 ns the experiments indicate displacement of the rear of the foil to 100 μ, growth of the perturbations to amplitudes exceeding 4 μ, and possible saturation, thereafter.

This evolution has been modeled with both 2D LASNEX, and the RAGE Eulerian code. LASNEX predictions were obtained both for 3T grey diffusion, LTE multi-group diffusion, and NLTE, using both pure Lagrangian and mixed Lagrangian-Eulerian hydrodynamics. RAGE employed 2T grey diffusion and automatic-mesh-refinement for high resolution. The relative efficiency in simulating this phenomenology and various discrepancies contingent on our modeling approaches will be discussed.

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THP14

Polarization Smoothing for ICF with MegaJoule Class Lasers

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Recent simulations have shown that filamentation[1] and stimulated Brillouin scattering[2] in an ICF hohlraum plasma are dramatically suppressed by polarization smoothing (PS),[3] which is the superposition on target of two orthogonally polarized and distinct speckle patterns. As a result, a significant improvement in laser performance and focal spot size may result from the use of PS, which might eliminate or reduce the need for smoothing by spectral dispersion (SSD) and its associated divergence. The essential requirements for an implementation of PS to be optimally effective are that the beam power be split equally between the polarizations and that the orthogonally polarized speckle patterns be completely uncorrelated. PS is being tested on Nova using slightly wedged KDP crystals which split the UV beam into orthogonally polarized beams with a small angular deviation. The prospects of this scheme for the upcoming MegaJoule scale lasers (i.e. NIF and LMJ), which requires the addition of a KDP crystal in each of ~ 200 UV beams, would appear to be hampered owing to the cost of implementation and increased damage threat and B - integral.

This paper examines the various possible implementations of PS, their practical implications for laser design, and their resultant smoothing effect on the target plane intensity distribution. A low cost alternative analyzed for PS on NIF or LMJ is to impose stress birefringence on an existing fused silica optic in either all or half of the UV beam paths. This approach adds no B - integral and requires little additional border around the optic. In the preferred scheme, a half-wave plate is created by stress birefringence which is nearly uniform over an entire aperture. In a second scheme one imposes a highly nonuniform stress pattern in an optic in every beam line. Analysis of these as well as the more conventional schemes of PS[3] are presented, both in terms of the ease of implementation, and the smoothing behavior as a function of spatial frequency on target.

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POSTER PRESENTATION PREFERRED

speckle spectrum can be affected by distribution of polarization rotation

Transmission through highly overdense plasma slabs with a subpicosecond relativistic laser pulse

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Experiments have been performed at CEA-Limeil-Valenton with the 80 TW P102 laser facility delivering 300 fs pulses at 0.529 μm at a maximum $I\lambda^2$ of 5×10^{18} $Wcm^{-2}\mu m^2$.

Transmission of this subpicosecond relativistic laser pulse is observed through thin solid foils. Significant transmission rates for densities above $10n_c$ are measured. A moderately relativistic strong threshold in intensity is found in order to observe this effect. Reflected and transmitted spectra near the fundamental laser wavelength are shown to broaden as transmission occurs. Near field imaging exhibits pinching of the pulse through the foil. The experimental results are discussed with the help of 2D-PIC simulations showing an increased expansion of the initially solid foils due to the fast electrons generated during the interaction.

These results have important implications in the fast ignition scheme for Inertial Confinement Fusion.

Prefer poster session.

THP16

2D Simulations of Multimode Perturbations in Ablatively Driven Foils.

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The ablation front mixing zone evolution from multimode initial conditions, similar to that of a DPP smoothed beam, is investigated numerically for 20, 40 and 90 micron ablatively driven plastic foils. The results of full numerical simulations are compared with nonlinear models [1]: modal [2,3] and bubble-merger [4,5]. The difference between several measures of the mixing zone width, such as the optical depth modulation, the real-space modulation and the average rising bubble height is discussed.

The effect of foil finite thickness ($\lambda \approx d$) and large perturbation amplitudes ($h \approx d$) on the perturbation evolution is discussed.

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THP17

Simulations of SSD Smoothing of Laser Nonuniformity in Directly Driven Foils.

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A model for the description of SSD smoothing of laser nonuniformity [1] in directly driven ICF is described. The effect of the limited integration time due to the creation of an ablated corona and the SSD bandwidth on the achievement of the full smoothing potential of SSD is discussed. This is done using a two-dimensional representation of the three-dimensional perturbation spectrum. Several options for such a representation are shown. The effect of the pulse shape on the smoothing efficiency is discussed.

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THP18

The "Return" of the Electron Beam

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For many years now, we[1] have proposed that the only reasonable explanation for the many observations of "Raman" scattering is the presence of electron beams in plasma. [The beams create a bump-on-tail (BOT) instability.] The primary objections to this explanation have remained the same: (a) How do you account for the Raman when $n_c/4$ surfaces are absent? (b) These beams move out of the plasma and must bounce and return before they can excite the Raman-like EPW's. Recent experimental results on OMEGA and at LULI[2] have suggested a new origin for these electron beams. This new scenario answers the two objections above, maintains electron beams as the explanation of the older experiments, and may clear up several puzzling observations that have remained unexplained to this day.

The new scenario is based on two assumptions:

1. Surprisingly high positive potentials develop in target plasmas during their creation (see R. Petrasso, this conference).
2. The high-intensity interaction laser beam initiates local gas breakdown that develops into a spark discharge (lightning-like) from nearby structures to the target plasma.

The resulting return current of electrons should be quite beam-like and initiates the BOT instability. Scattering of the interaction beam, or a Thomson probe, from these waves yields the Raman signal that is observed. Experimental observations that tend to support this picture will be cited. These include the LULI results and numerous older Raman experiments. For example, "pulsation" of the scattering and broadband "flashes" are a natural part of this scenario. In this picture, laser beam smoothing (RPP) should result in reduced Raman.

Prefer poster session.

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Nonlinear Evolution of the 3-D Broad-Bandwidth Spectrum of Imprinting in Planar Targets Accelerated by UV Light

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The three-dimensional, late-time evolution of the imprinting pattern is studied in planar-foil experiments on the OMEGA laser system. Smooth, initially unperturbed, CH_2 targets are irradiated with 3-ns square pulses at 2×10^{14} W/cm^2 using five beams focused to 800 μm spots. Growth of perturbations seeded by irradiation nonuniformities was observed using time-gated, pinhole photographs of ~1.2-keV x rays from a backlighter. A full characterization of the detector response and noise is used to extract the signal. The temporally evolving, filtered images of the target perturbations are well correlated. The Fourier transform spectrum of 2-D radiographic images shows the perturbations evolving to longer wavelength. We observe nonlinear saturation of broad-band imprinted features at levels similar to Haan's prediction.[1] Target images taken at different times show the formation of bubble and spikes from initial elongated "wormy" structures.

Prefer poster session.

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THP20

Reduction of early-time perturbation growth in ablatively driven planar laser targets using tailored density profiles

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We investigate numerically the effect of tailoring the density profile in the target in order to decrease imprinting of mass perturbations due to the long-wavelength modes. Perturbation growth in ablatively accelerated targets has recently been demonstrated to saturate during the shock transit time due to the stabilizing effect of mass ablation [1, 2]. The saturation time scales as the perturbation wavelength, hence the short-wavelength perturbations saturate early, restricting the damage to the target to the long-wavelength modes [3]. The idea, first suggested for mitigating the RT instability of an imploding Z-pinch [4], is to invert the acceleration of the unstable surface (ablation front) during the shock transit time, as the shock wave slows down propagating into higher density layers. Then the effective gravity near the ablation front has the same direction as the density gradient, hence the mass perturbations near it oscillate instead of growing exponentially. We compare evolution of small perturbations due to surface roughness and non-uniformity of the laser beam in planar targets with flat and tailored density profiles and demonstrate the decrease in perturbation growth for the latter case.
Work sponsored by US DOE.

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Prefer Poster Presentation

Propagation of Fast Electrons into Thick Solid Targets in High Intensity Laser-Solid Interactions

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Novel features associated with the fast electron transport when short pulse (~1 ps) high intensity (~10^{19} Wcm^{-2}) laser pulses illuminate thick (50-250 μm) solid targets are presented. Plastic and Aluminium targets have been examined. The observations are based on laser probing diagnostics. A plasma is observed on the rear surface of the target exactly in line with the laser focus when the focused intensity onto the front surface of the target exceeds 10^{18} Wcm^{-2}. The earliest time that such a plasma is observable is at 22 ps for a 140 μm thick CD_2 target. This plasma is generated by a beam of fast electrons travelling through the target. The fast electron beam is collimated by the self generated magnetic field within the target and this is in agreement with simulations based on a Fokker-Planck hybrid code in r-z geometry. For lower intensities on the target the plasma on the rear surface is observed to diverge from the focal line indicating that an instability has developed.

Poster presentation

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ORAL SESSION I

D. Meyerhofer, Chair

Friday, 19 June 1998

Submitted to the 28th Anomalous Absorption Conference, June 1998

Interaction of an ultraintense laser pulse with an overdense plasma: relativistic electron, ion, and neutron production

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The 2D fully relativistic parallel Particle In Cell code MANET has been used to study the interaction of ultrahigh intensity laser pulses with critical and overcritical plasmas. Experimentally relevant situations have been modeled, with ten-terawatt sub-picosecond laser beams focused to focal spots of a few wavelength FWHM diameters, reaching irradiances of many 10^{18} W/cm^2.

In the area where the incident wave interacts with the plasma, a large number of electrons are strongly kicked into the target with relativistic energies. The resulting high current is the prime mover in the "fast ignitor" scheme, and therefore we paid special attention to the angular and kinetic energy distribution of these electrons, and to the fraction of incident laser energy that can be converted into electron kinetic energy. The large ion inertia prevents direct acceleration by the laser, but plasma ions can nonetheless be accelerated to high energies by the space charge fields generated through electron acceleration. The ion wave dynamics and ion acceleration have also been investigated and quantified.

When the laser is incident on a deuterated target, energetic D^+ ions can inelastically collide with the D atoms of the target and produce thermonuclear neutrons. A post-processor for MANET has been developed to estimate the ion trajectories in the target, and calculate the angle and energy distribution of the produced neutrons. The results are compared to recent experiments performed on the P102 laser at CEA/Limeil.

F02

Oblique Stimulated Raman Scattering of a Short Laser Pulse in a Plasma Channel

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The spatiotemporal evolution of parametric instabilities such as stimulated Raman scattering (SRS) is studied analytically in time and two spatial dimensions. Initial and boundary conditions are chosen to represent the entrance, propagation, and exit of a laser pulse of finite extent convecting through a homogeneous collisional plasma channel with definite boundaries. For most scattering angles partial reflection of the Stokes radiation enhances the growth so that for large times one-dimensional damped modes are formed in which the convective loss created by the transmission of the Stokes wave through the channel boundaries is equivalent to an overall damping of the Stokes amplitude within the channel.

Prefer oral session.

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28th Anomalous Absorption Conference, Bar Harbor, Maine June 14-19 1998

Filamentation of a 500fs laser beam at 1053nm wavelength over long distances in air

by

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ABSTRACT

We have studied the propagation of a high-power short-pulse laser beam over considerable distances in air, both experimentally and via numerical simulations, with a view to examining the feasibility of such beams for controlling and directing electrical breakdown in the laboratory and in field tests. We have observed the propagation of such a beam for distances of up to 50 meters. The early values of plasma electron density have been inferred to be about 10^{16} cm^{-3} using longitudinal spectral interferometry in a novel way. The lateral dimensions of these filaments increase significantly after about 20 meters and the pulse energy in the filament stabilizes at about 1.5 to 2.0 mJ, after about 35 meters. The results have been modeled in several ways, based on a particular form the nonlinear Schrödinger equation in which one includes the cumulative effects of multi-photon ionization.

F04

28-th Annual Anomalous Absorption Conference

Channel formation and high energy ions generation in interaction of short intense laser beam with an underdense plasma

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We report on the interferometric observations of the dynamics of electron-ion cavitation produced by the relativistically self-focused intense 4 TW, 400 fs laser pulse followed by high energy ions generation in a He gas jet. Stable 1 mm long and less than 30 μm in diameter channel has been observed with the electron density which drops approximately 10 times from the maximum value of $\sim 8 \cdot 10^{19}$ cm^{-3}. High radial velocity of the surrounding gas ionization $\sim 3.8 \cdot 10^{8}$ cm/s has been observed about 10 ps after the channel formation and it is attributed to the fast ions with the energy more than 300 keV expelled from the laser channel and propagating radially outwards. The total energy of fast ions is estimated to be about 6% of the laser pulse energy. We developed a kinetic model, which describes an ion and electron expulsion from the laser channel and a subsequent ambient gas atoms excitation and ionization due to the inelastic ion collisions. This model allows one to relate the interferomic observations of the plasma refraction coefficient to the parameters of fast ions and laser channel characteristics. The model is in a good agreement with observations. It demonstrates a new possibility for a direct transmission of a significant part of laser pulse energy into fast ions.

1524

F05

Absorption of Ultra-short, Ultra-intense Laser Light by Solids and Over-dense Plasmas*

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We report on the recent progress in understanding the difficult and important problem of the absorption of laser light as it interacts with plasmas or solids. A combination of 2 _ PIC simulations and Monte Carlo electron transport simulations have provided considerable insight into this new regime of ultra-relativistic laser-plasma interactions. This theoretical work suggests that it may be possible to transfer a substantial amount (~10-40%) of the energy in ultra-short laser pulses into very hot electrons (> 1 MeV.) These electrons could potentially be useful in either providing a fast ignition of a pre-compressed DT fusion pellet, or in the generation of a very intense burst of energetic x-rays for laser radiography. We discuss various absorption mechanisms, the directionality of the electrons, and ways to enhance the absorption of laser energy into these electrons. To complement this study, comparison to results from recent experimental campaigns at LLNL with the PetaWatt laser (400 Joules, _ picosecond laser pulse, focused to roughly 25 micron spot) will also be discussed. In particular, information about the hot electrons gained from K-α spectroscopy, buried layer techniques, direct electron measurements using an electron spectrometer (where energies up to 80 MeV have been observed) will be presented.

*Work performed under the auspices of the U.S. D.O.E.. by LLNL under contract number W-7405-ENG-48.

F06

Stimulated Brillouin Scattering in High-Intensity, Self-Focused Filaments: The Effects of Sound Wave Diffraction and Plasma Flow

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There is now considerable evidence that stimulated Raman scattering (SRS) often occurs in high-intensity self-focused filaments in laser-produced plasmas. The situation regarding stimulated Brillouin scattering (SBS) is less clear. Here we study one of the most important differences in these two instabilities: the propagation of the electrostatic wave in the filament. In the case of SRS the electron-plasma wave that does the scattering is confined to the filament as a waveguide mode along with the pump and scattered light waves. In the case of SBS, however, an ion sound wave is responsible for the scattering, and, owing to the weak dependence of the sound wave dispersion relation on the plasma density, the sound wave is not confined to the filament. Thus, propagation of the sound wave out of the filament due to diffraction or to plasma flow through the filament can represent a significant energy loss mechanism for SBS. These effects may tend to suppress SBS in small filaments. The significance of these effects is investigated as a function of filament size and intensity, and recent experimental results are considered in light of the results.

Prefer oral session.

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Accurate Formulas for the Landau Damping Rates of Electrostatic Waves

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The convective gain factors of parametric instabilities such as SBS and SRS depend sensitively on the damping rates of the daughter waves.[1,2] We use systemic perturbation methods to derive formulas for the frequencies and Landau damping rates of electron-plasma and ion-acoustic waves. The predictions of our formulas are compared to the predictions of textbook formulas[3–5] and numerical solutions of the electrostatic dispersion equation. When $(k\lambda_e)^2 < 0.1$ (for electron-plasma waves) and $T_i/ZT_e < 0.1$ (for ion-acoustic waves), our formulas are more accurate than the textbook formulas. When $(k\lambda_e)^2 > 0.1$ and $T_i/ZT_e > 0.1$, no pair of formulas is accurate and the electrostatic dispersion equation must be solved numerically.

Prefer oral session.

This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

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F08 Posterized last night

Nonlinear theory of power transfer between multiple crossed laser beams in a flowing plasma

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Analytic results are obtained for power transfer among crossing, equal frequency, laser beams, each smoothed by a random phase plate, in a flowing homogeneous plasma. For beams with well separated directions, inter-beam coupling transfers power, while intra-beam coupling causes beam deflection. For any pair of such beams, the beam with the largest positive projection on the flow direction will drain power from the other.

For nominal NIF parameters, with strongly damped acoustic waves and a flow Mach number of 0.5, significant transfer between the inner and outer cones of laser beams occurs over a short distance, of order 100 μm.

Since the wavenumbers and associated acoustic frequencies of the density fluctuations which mediate inter-beam couplings are larger and hence less susceptible to temporal smoothing than intra-beam couplings, it is possible that a given amount of temporal bandwidth (either externally imposed or self induced) is at once both adequate to suppress self focusing and inadequate to suppress inter-beam power transfer.

prefer oral presentation

F09

Put at Th O 13

Theoretical analysis of Thomson scattering from laser produced plasmas*.

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Thomson scattering is a powerful diagnostic of laboratory plasmas. Its utility is greatly enhanced when used with relevant theoretical models of electron density fluctuations and scattering cross-section. This is illustrated by the analysis of the scattering data from gold plasmas produced by one Nova beam irradiating a disk target [1] and colder plasmas from solid targets at lower laser intensities [2].

An expression for the Thomson scattering cross-section in inhomogeneous plasmas is derived and applied to experimental results. Analysis of simultaneous measurements of Thomson scattered light with the frequency shifts corresponding to ion-acoustic and Langmuir resonances is used to determine electron density, temperature, plasma flow and average ionization state in stable plasmas close to equilibrium. In hot, dense plasmas inhomogeneities of the flow and density increase the width of resonance lines in the scattered light spectra, far beyond broadening due to particle collisions. On the other hand asymmetry in the intensity of ion-acoustic resonances allows for the calculations of a heat flux and a thermal transport coefficient.

High-Z plasmas and increased Thomson probe intensity result in plasma conditions relevant to theoretically predicted super-Gaussian distribution functions. No effects in fluctuation spectra due to these distribution functions have been found experimentally. Measurements show, however, increased levels of fluctuations which could be related to a return current instability.

[1] S. H. Glenzer, C. A. Back, K. Estabrook, and B. J. MacGowan, Rev. Sci. Instrum., **68**, 668 (1997).

[2] P. E. Young, Phys. Rev. Lett. **73**, 1939 (1994).

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F010

Two Plasmon Decay and Filamentation in a CO_2 Laser Produced Plasma

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For several years we have investigated the temporal evolution of the two plasmon decay instability in long scale length CO_2 laser produced plasmas using mainly picosecond, high spatial and wave vector resolution Thomson scattering of probe laser radiation. By changing the probe laser wavelength and observing both red and blue shifted scattered radiation we have significantly increased the wave vector resolution of the instability allowing for improved comparison with theoretical predictions. Most recently we have observed evidence, which link the two plasmon decay instability to filamentation. These experiments and their interpretation will be described in detail.

2nd Harmonic emission is consistent with narrow channel formation (filamentation)

Oral prefered Final Paper!

Analysis of forward cone is a good diagnostic of channel formation!

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28th Annual Anomalous Absorption Conference

14–19 June 1998

The Atlantic Oakes
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