Twenty-Ninth Annual
Anomalous Absorption Conference

Asilomar Conference Center
Pacific Grove, California
June 13-18th, 1999

Hosted by LLNL's Institute for Laser Science and Applications

Conference Organizers: Scott Wilks
Peter Young
Hector Baldis

Conference Secretaries: Mary Ann Soby
Jennifer Cook

Monday June 14, 1999
Merrill Hall

8:15AM Introductory Remarks Co-chairs

Oral Session 1 Ultra-Intense, Short Pulse Interactions (E. Lefebvre, Chair)

8:30AM **101** Thin foils heated by 100 fs 10^{18} W/cm^2 laser pulse
P. Audebert, R. Shepherd, D. Price, K. Fournier, R. Lee, and P. Springer

8:45 **102** Electron Acceleration and Absorption in Laser Channel
K. Mima, Y. Sentoku, K. Tanaka, Y. Kitagawa, R. Kodama, and T. Yamanak

9:00 **103** High absorption, large current generation and transport in ultra-intense laser-plasma interaction
H. Ruhl, F. Coronolti, S. Hain, A. Macchi, P. Mulser, F. Pegoraro, and S. Sentoku

9:15 **104** Multi-Megagauss Magnetic Field Generation and Ion Transport inside Solids from Ultra-intense Laser-Solid Interactions
E.L. Clark, K. Krushelnick, F.N. Beg, M.I.K. Santala, M. Tatarakis, I. Watts, M. Zepf, A.E. Dangor, P.A. Norreys, J.R. Davies, A. Machecek, J.S. Wark, K.W.D. Ledingham, T. McCanny, and I. Spencer

Experiment identification of "Vacuum Heating" at Femtosecond-Laser-Irradiated Metal Surfaces
A. Rundquist, M. Grimes, Y.-S. Lee and M. Downer

9:45 **106** Interactions of picosecond pulses with strongly overdense plasmas
J.C. Adam and A. Heron

10:00 **107** Study of the interaction of ultra-intense laser pulses with solid targets on the Petawatt laser system
A. J. MacKinnon, C. G. Brown, T. Ditmire, S. Hatchett, J. Koch, M. H. Key, J. Moody, A.A. Offenberger, D. Pennington, M. D. Perry, M. Tsukamoto, and S. C. Wilks

10:15 BREAK

Oral Session 2 – Laser Plasma Interactions (S. Glenzer, Chair)

10:30 **201** Simulations of OMEGA Long-Scale-Length Plasmas Representative of the Transition Portion of NIF Direct-Drive Pulses
R.S. Craxton, D.D. Meyerhofer, S.P. Regan, W. Seka, R.P.J. Town, and B. Yaakobi

10:45 **202** Laser-Plasma Interactions in Plasmas Characteristic of the Direct Drive NIF Foot-to-Main Drive Region
D.D. Meyerhofer, R. Bahr, R.S. Craxton, S.P. Regan, W. Seka, R. Short, A. Simon, R.P.J. Town, and B. Yaakobi

11:00 **203** Designs of He/H2 filled gasbag experiments on Nova
C.D. Decker, R.L. Berger, J.D. Moody, E.A. Williams, L.J. Suter, and L. Lours

11:15 **204** Measurements of SRS and SBS backscattered light from He/H2 cryogenic Nova gasbag targets
J.D. Moody, B.J. MacGowan, C.D. Decker, S.H. Glenzer, R.K. Kirkwood, P.E. Young, R.L. Berger, G.W. Collins, C.G. Geddes, J.A. Sanchez, L.J. Suter and E.A. Williams

11:30 **205** Observed Insensitivity of Stimulated Raman Scattering on the Damping Rate of Electron Plasma Waves
J.C. Fernandez, J.A. Cobble, D.S. Montgomery, and M.D. Wilke

11:45 **206** Super-thermal Self-Consistent SRS Seed
H.A. Rose

12:00 **207** The evolution of the frequency and wavenumber of the transmitted and reflected light in 3D simulations
R. L. Berger, A.B. Langdon, D.E. Hinkel, C.H. Still, and E.A. Williams

12:15 **208** Optical Mixing Controlled Stimulated Scattering Instabilities: Effects of a Large Amplitude Probe Beam on the Backscattering of a Pump Beam
B.B. Afeyan, J. Fleischer, C. Geddes, D. Montgomery, R. Kirkwood, K. Estabrook, A. J. Schmitt, D. Meyerhofer, and R.J.P. Town

12:30 Session ends

Invited Talk 1

7:00 PM **1IT** Short-pulse laser-solid interactions, *A. Bell*

8-11 PM Poster Session 1

1P1 Backscatter and Transmitted Beam Measurements at Omega for Optical Mixing and Other Experiments
C.G.R. Geddes, B.B. Afeyan, J.W. Fleischer, R.K. Kirkwood, D.S. Montgomery, D.Meyerhofer, W. Seka, K. Estabrook, A.J. Schmitt, R.P.J. Town, and S. Alvarez

1P2 Laser-plasma interaction in megajoule cavities
M. Casanova, L. Divol, P. Loiseau, and D. Mourenas

1P3 The Competition of Stimulated Raman and Brillouin Backscatter in LULI Multiple Laser Beam Experiments
B.I. Cohen, H.A. Baldis, R.L. Berger, C. Labaune, K.G. Estabrook, C.H. Still, and E.A. Williams

1P4 Interaction of Two Crossed RPP Laser Beams with a Plasma
A. Maximov, I. Ourdev, W. Rozmus, D. Pesme, H.A. Baldis, C. Labaune, and C.E. Capjack

1P5 Two-dimensional PIC Simulations of SBS in Multiple Laser Hot Spots
C. Riconda, S. Huller, J. Myatt, D. Pesme, and Ph. Mounaix

1P6 Ion plasma waves induced by electron oscillations
R.P. Drake and R.S. Marjoribanks

1P7 The effect of kinetic processes on parametrically excited Langmuir turbulence
K. Sanbonmatsu, H.X. Vu, D.F. DuBois and B. Bezzerides

1P8 Direct drive cylindrical Implosions on the OMEGA laser
C.W. Barnes, D.L. Tubbs, S.H. Batha, J.B. Beck, R.D. Day, N.D. Delameter, N.M. Hoffman, P. Gobby, J.A. Oertel, J.M. Scott, N.A. Shambo, R.G. Watt, T.R. Boehly, D.K. Bradley, P. Jaanimagi, J.P. Knauer, A.M. Dunne, S. Rothman, D.L. Youngs, D. Haynes, and C. Hooper

1P9 Computations of Megabar Pressure Waves through Low Density Foams Filled with Liquid Deuterium
J.L Dahlburg, J. D. Sethian, V. Serlin, D. Colombant, J.H. Gardner, and M. Klapisch

1P10 Modeling of CH Plastic Targets Coated with Thin Gold Layers
J.H. Gardner, S.P. Obenschain, V. Serlin, D. Colombant and M. Klapisch

1P11 Hydrodynamic Simulations of Static and Dynamic Laser Imprint
Y. Srebro, D. Oron, D. Shvarts, T.R. Boehly, V.N. Goncharov, O. Gotchev, V.A. Smalyuk, S. Skupsky, and D.D. Meyerhofer

1P12 The Effect of Interference on the Uniformity of Energy Deposition in Laser Driven Implosions
Z. Yasin, and S.A. Vagar

1P13 Kinetic-Theory Foundations and Radiation-Hydrodynamics Approaches to Laser-Matter Interactions
V.L. Jacobs

1P14 Time-resolved Symmetry Measurements using Reemission Technique in Scale-3 Hohlraums at Omega
N.D. Delameter, G.E. Magelssen, S. Evans, J. J. MacFarlane, N. Landen, P. Amendt, D. Bradley, and G. Glendinning

1P15 NIF ignition capsules with high Z pushers
D.C. Wilson and P.A.Bradley

1P16 P6 and P8 modes in NIF hohlraums
S. Pollaine, D. Bradley, O. Landen, R. Wallace, O. Jones, P. Amendt, G. Glendinning, R. Turner, and L. Suter

1P17 Modeling Radiation Drive in Half-Hohlram Geometry
B. F. Lasinki, L.J. Suter, K. S. Budil, C. A. Back, S. G. Glendinning, R. E. Turner, J. Edwards, J. D. Bauer, and A. S. Wan

1P18 Development of a δf Scheme for Studying Transport of Nonthermal Particles
S. Brunner, E. Valeo, and J. Krommes

1P19 Two Dimensional Hybrid δf Code Development
E. Valeo, S. Brunner, and J. Krommes

1P20 Modified electron distribution function due to inverse brensstrahlung absorption and nonlocal transport
E. Fourkal, V. Yu. Bychenkov, W. Rozmus, R. Sydora, C. Kirkby, and C.E. Capjack

1P21 A tractable model for non-local electron heat transport in 2 or 3 dimensions hydrodynamic codes
M. Busquet, Ph. Nicolai, and G. Schurtz

1P22 Table Top Transient Collisional X-ray Lasers
V. Shlyaptsev, J. Dunn, A.L. Osterheld, Y. Li, and J. Nilsen

1P23 Tertiary Neutron Diagnostic by Carbon Activation
V. Yu. Glebov, D.D. Meyerhofer, P.B. Radha, W. Seka, S. Skupsky, J.M. Soures, and C. Stoekl

1P24 Requirements for NIF's soft-xray drive diagnostic
L. Suter, J. Porter, J. Bourgaude, R. Kauffman, W. Simmons, and R. Turner

1P25 Time- and Space-resolved X-ray Spectroscopy for Investigation of Fusion Pellet Implosion
Y. Ochi, K. Fujita, H. Nishimura, M. Fukao, I. Niki, T. Kawamura, A. Sunahara, M. Heya, H. Shigara, N. Miyanaga, H. Azechi, H. Takabe, K. Mima, T. Yamanaka, S. Nakai, R. Butzbach, I. Uschmann, and E. Foerster

Tuesday June 15, 1999

Oral Session 3 – Physics of Direct Drive (Mima, Chair)

8:30 AM **3O1** Planar Burnthrough Experiments on OMEGA amd NIKE
S.P. Regan, J.A. Delettrez, T.R. Boehly, D.K. Bradley, J.P. Knauer, D.D. Meyerhofer, C. Stoeckl, S. Obenschain, T. Leheka, C. Pawley, Y. Aglitskiy, V. Serlin, J. Gardner

8:45 **3O2** Analysis of Planar Burnthrough Experiments on OMEGA and NIKE
J.A. Delettrez, S.P. Regan, T.R. Boehly, C. Stoeckl, D.D. Meyerhofer, P.B. Radha, J. Gardner, Y. Aglitskiy, T. Lehecka, S. Obenschain, C. Pawley, and V. Serlin

9:00 **3O3** Simulation of the Radiative Preheat of Target Foils and Shells in Laser-Driven Ablation and Implosion Experiments
R. Epstein, T.J.B. Collins, J.A. Delettrez, V.N. Goncharov, S. Skupsky, R.P.J. Town, and B. Yaakobi

9:15 **3O4** X-ray imaging diagnostics for the inertial confinement fusion experiments
Y. Aglitskiy, T. Lehecka, S. Obenschain, C. Pawley, C.M. Brown, and J. Seely

9:30 **3O5** Modeling of Laser Imprint for OMEGA and NIF Capsules
V.N. Goncharov

9:45 **3O6** The fully developed stage of Radiative Plasma structures
G. Hazak, A.L. Velikovich, M. Klapisch, A. J. Schmitt J.P. Dahlburg, D.G. Colombant, J.H. Gardner, L. Phillips, and N. Metzler

10:00 **3O7** Reduction of Mass Perturbation Seeds in Direct-Drive Laser Targets Using Tailored Density Profiles
N. Metzler, A.L. Velikovich, J.H. Gardner, J.P. Dahlburg, and A.J. Schmitt

10:15 BREAK

Oral Session 4 – Laser Plasma Interactions (Meyerhofer, Chair)

10:30	**401**	Thomson scattering on Ion Waves Driven by SBS in Large Scale Length Plasmas *S.H Glenzer, C.G. Geddes, R.K. Kirkwood, B.J. MacGowan, J.D. Moody, and P.E. Young*
10:45	**402**	The Spatial Location of Stimulated Electrostatic Waves in a Long Homogeneous, Laser-produced Plasma *J.A. Cobble, J.C. Fernandez, N.A. Kurnit, D.S. Montgomery, R.D. Johnson, N. Renard-Le Galloudec and M. R. Lopez*
11:00	**403**	Analysis and Simulation of Sound Waves Governed by the Korteweg-de Vries Equation *C.J. McKinstrie and M.V. Kozlov*
11:15	**404**	Experimental Study of the Affect of Speckle Size on Backscatter in a Phase Plate Smoothed Beam *R.K. Kirkwood, R.L. Berger, C.G. Geddes, S.H. Glenzer, A.B. Langdon, B.J. MacGowan, J.D. Moody, and P.E. Young*
11:30	**405**	Instabilities of a Single Laser Filament in a Plasma *V.T. Tikhonchuk, D. Pesme, W. Rozmus, A. Maximov, C.H. Still, V. Eliseev, and C.E. Capjack*
11:45	**406**	Flow-induced beam steering in the Trident single hot spot experiments *D.S. Montgomery, R.P. Johnson, J.A. Cobble, J.C. Fernandez, H.A. Rose, H. X. Vu, N. Renard- Le Galloudec*
12:00	**407**	Nonlinear Hydrodynamic Simulations of SBS in Laser Hot Spots *J. Myatt, S. Huller, D. Pesme, and C. Riconda*
12:15PM	**408**	Forward SBS, Filamentation and SSD *R.W. Short*

Invited Talk 2

7-8PM	**2IT**	Nonlinear propagation of laser beams in plasmas, *W. Rozmus*

8-11 PM Poster Session 2

2P1	Stimulated Brillouin Scattering in the Presence of a Filamenting Pump, Non-Local Heat Transport, and a Turbulent Plasma *B.B. Afeyan, J.W. Fleischer, A.J. Schmitt, and R.J.P. Town*
2P2	Imprint modeling in direct-drive laser-fusion pellets *A.J. Schmitt, B.B. Afeyan, and J.H. Gardner*
2P3	I*L Statistics of Filamenting Laser Beams: Statistical Properties of Laser Beams Propagating in Inhomogeneous Plasmas Near or far from Their Turning Points *J.W. Fleischer, B.B. Afeyan, and A.J. Schmitt*
2P4	Two-dimensional simulations of Raman and two-plasmon scattering in a modulated-density plasma *M. Curtet, S. Charpentier, E. Lefebvre, and G. Bonnaud*
2P5	Numerical Two-Dimensional Studies of Near-Forward Stimulated Brillouin Scattering of a Laser Beam in Plasmas *A.V. Kanaev and C.J. McKinstrie*
2P6	Photon Kinetics for Laser-Plasma Interactions *L.O. Silva, W.B. Mori, R. Bingham, J.M. Dawson, T.M. Antonsen, and P. Mora*
2P7	Suppression of Raman gain in an inhomogeneous plasma by finite amplitude ion acoustic waves *T.J.M. Boyd, H.C. Barr, and A.V. Lukyanov*
2P8	Spectral Evidence for Collisionless Absorption in Sub-Picosecond Laser-Solid Interactions *C.T. Hansen, S.C. Wilks, and P.E. Young*
2P9	Propagation of intense and short laser pulses through underdense plasmas: effect of the laser intensity and of the plasma density *C. Rousseaux, F. Amiranoff, S. Baton, J. Fuchs, L. Gremillet, J.L. Miquel, J.C. Adam, A. Heron, and P. Mora*
2P10	Channeling and filamentation of intense sub-picosecond laser pulses *D. E. Hinkel, A. B. Langdon and C. H. Still*

2P11 Particle-in-cell Simulation of Ponderomotive Particle Acceleration in a Plasma
E.A. Startsev and C.J. McKinstrie

2P12 Ultra-Intense Laser Plasma Effects: Gigagauss magnetic fields, relativistic electron beams, and ultra-high target potentials
W.L. Kruer, K.A. Tartt, and S.C. Wilks

2P13 Experimental Studies of three-halves harmonics from Al target irradiated by ultra-intense laser light
M. Mori, Y. Kitagawa, R. Kodama, K.A. Tanaka, H. Habara, T. Koase, S. Nakata, K. Suzuki, K. Sawai, Y. Sentoku, K. Mima, T. Yamanaka, and S. Nakai

2P14 High brightness electron beams produced by laser ionization of gases
C.I. Moore, A. Ting, S. McNaught, T. Jones, B. Hafizi, and P. Sprangle

2P15 Laser Pulse Propagation through a Thin Lens
C. Ren, B.J. Duda, W.B. Mori, T.M. Antonsen, Jr.,T. Katsouleas, and P. Mora

2P16 Ablative Rayleight-Taylor Instability in Indirectly Driven thin Aluminum Foils
J. Edwards, B. Lasinski, K. S. Budil, A. S. Wan, B. A. Remington, L. Suter, P. E. Stry and S. V. Weber

2P17 Simulation of Rayleigh-Taylor Growth in Buffered Radiatively Driven Planar Thin Foils
R.J. Mason, D.E. Hollowell, G.T. Schappert, S. Batha, and M. Gittings

2P18 Rayleigh-Taylor Instability Initiated by Acoustic Waves
N. Hoffman

2P19 Radiative hydrodynamics experiments for astrophysics
K. Shigemori, T. Ditmire, B.A. Remington, K.G. Estabrook, D.R. Farley, D.D. Ryutov, A.M. Rubenchik, R. Kodama, T. Koase, Y. Ochi, and H. Azechi

2P20 Shock compressed solids on the Nova laser
D.H. Kalantar, B.A. Remington, J.D. Colvin, D.M. Gold, K.O. Mikaelian, S.V. Weber, L.G. Wiley, A. Loveridge, J.S. Wark, M. Meyers, and A. Hauer

2P21 Ablative Rayleigh-Taylor Instability in Spherically Convergent Geometry
G. Glendinning, O.L. Landen, B.A. Remington, R.J. Wallace, D. Galmiche, C. Cherfils, P.A. Holstein, and A. Richard

2P22 Ablator Characteristic Experiments on Nova with Brominated plastic and Copper doped Beryllium
E. de Prandieres, J.P. Jadaud, N. Dague, L. Divol, S.V. Weber, and G.W. Collins

2P23 Electron and Ion Jet Formation in Ultra Intense Laser Plasmas
Y. Sentoku, K. Mima, H. Ruhl, S.V. Bulanov, R. Kodama, and K.A. Tanaka

2P24 LLNL Nova and Gekko laser experiments of radiative astrophysical jets
K. Estabrook, B. Remington, K. Shigemori, D. Farley, S. Glenzer, R. E. Turner, G. Glendinning, G. Zimmerman, J. H. Harte, D. S. Bailey, R. J. Wallace, R. W. Lee, K. Fournier, R. Kodama, R. Koase, Y. Ochi, H. Azechi, J. Stone and N. Turner

2P25 Hydrodynamic Instabilities in Supernova Remnant Simulation Experiments
R. P. Drake, T. Smith, H.N. Reisig, S. Gail Glendinning, K. Estabrook, O. Hurricane, B. A. Remington, R. Wallace, J. J. Carroll III, E. Michael, Richard McCray

Wednesday, June 16, 1999

Oral Session 5 – Direct Drive/ Laser Plasma Interactions (Schmitt, Chair)

8:30 AM **501** Imaging of Compressed Shells with Imbedded Thin, Cold, Titanium-Doped Layers on OMEGA
V.A. Smalyuk, F.J. Marshall, D.D. Meyerhofer, and B. Yaakobi

8:45 **502** A plasma piston for radiation hydrodynamics experiments
J. Edwards, S.G. Glendinning, L.J. Suter, T.D. Shepard, R.E. Turner, K.S. Budil, B. Lasinski, A.S. Wan, B.A. Remington, P. Graham, A.M. Dunne, and B.R. Thomas

9:00 **503** F3D Simulations of the Propagation of Nova Beams in Gas-bag Targets
E.A. Williams, A.B. Langdon, C.H. Still, R.L. Berger and S.N. Dixit

9:15 **504** Progress for the parallel LPI design code pF3D
C.H. Still, R.L. Berger, A.B. Langdon, E.A. Williams and D.E. Hinkel

9:30 **505** The Role of Hot Electrons and Langmuir decay Instability on the Development and Saturation of Stimulated Raman Scattering
H.X. Vu, K.Y. Sanbonmatsu, B. Bezzerides and D.F. DuBois

9:45 **506** Laser-Plasma Interactions in the 350 eV National Ignition Facility Target
D.E. Hinkel and S.W. Haan

10:00 **507** Quasilinear Transition from Compton to Raman Scattering
C.S. Liu aand V. Tripathi

10:15 BREAK

Oral Session 6 - Ultra Intense, Short Laser Pulse (Kruer, Chair)

10:30 **601** The dependence on the density scale length of the directionality of the electron beam and the generation of ultra-large magnetic fields in relativistic laser plasmas
P.A. Norreys, R. Allott, F.N. Beg, E. Clark, R.J. Clarke, A.E. Dangor, K. Krushelnick, K.W.D. Ledingham, A. Machacek, T. McCanney, D. Neely, M. Santala, R.P. Singhal, I. Spencer, M. Tatarakis, J.S. Wark, I. Watts, S.C. Wilks, and M. Zepf

10:45 **602** Laser-Driven Nuclear Fission, Positron Creation and Electron Acceleration in Ultra-Intense Laser-Solid Experiments on the Petawatt
T.E. Cowan, A.W. Hunt, J. Johnson, M. Roth, C. Brown, W. Fountain, S. Hatchett, E.A. Henry, M.H. Key, T. Kuehl, T. Parnell, D.M. Pennington, M.D. Perry, T.C. Sangster, M. Singh, R. Snavely, M. Stoyer, Y. Takahashi, and S.C. Wilks

11:00 **603** Energetic Particle and Photon Production with Ultra-Intense Lasers
E. Lefebvre, C. Toupin and G. Bonnaud

11:15 **604** Fusion Neutron spectroscopy as a diagnostic tool for relativistic laser-plasma interaction
S. Karsch, G. Pretzler, D. Habs, M. Gross, U. Schramm, P.G. Thirolf and K.J. Witte

11:30 **605** Fast Ignition Studies using Ultra-Intense CPA Lasers at ILE
Y. Kitagawa, R. Kodama, K. Tanaka, H. Fujita, K. Mima, T. Yamanaka, T. Norimatsu, N. Izumi, J. Sunahara, Y. Sentoku, K. Takahashi, H. Habara, M. Mori, T. Matsushita, and T. Sono

11:45 **606** Experimental studies of tabletop, laser driven deuterium cluster fusion
J. Zweiback, V.P. Yanovsky, T.E. Cowan, G. Hays, K.B. Wharton, and T. Ditmire

12:00 **607** Laser-Driven Micro Neutron Sources for Fusion Material Irradiation at High Flux and Fluence
L.J. Perkins, B.G. Logan, T. Ditmire, P.T. Springer, S.C. Wilks, M.D. Rosen, M.D. Perry, T. Diaz de la Rubia, and N.M. Ghoniem

12:15 PM **608** Experimental Measurements of Deep Heating Generated by Ultra-Intense Laser-Plasma Interactions
J.A. Koch, M.H. Key, R.W. Lee, S.P. Hatchett, C. Brown, and D. Pennington

~~**12:30 – 1:00**~~ Business Meeting

7 – 11 PM Banquet – Monterey Bay Aquarium

Thursday June 17, 1999

Oral Session 7 - Novel applications (Amendt, Chair)

8:30 AM	701	Guiding large-scale electrical discharges with ultra-short laser pulses *B. La Fontaine, D. Comtois, C.-Y. Chien, A. Desparois, T. Johnston, J.-C. Kieffer, F. Martin, R. Mawassi, H. Pepin, F.A.M. Rizk, F. Vital, C. Potvin, P. Couture and H.P. Mercure*
8:45	702	Triggering of Large-Scale Electrical Discharges using Ultrashort laser Pulses *H. Pepin, D.Comtois, C.-Y. Chien, A. Desparois, T. Johnston, J.-C. Kieffer, B. La Fontaine, F. Martin, R. Mawassi, F.A.M. Rizk, F. Vital, C. Potvin, P. Couture and H.P. Mercure*
9:00	703	Experiments on a Radiative Collapse in Laser-Produced Plasmas Relevant to Astrophysical Jet Formation *R. Kodama, T. Koase, Y. Ochi, H. Nishimura, H. Azechi, K. Shigemori, D. R. Farley, K. G. Estabrook, B. A. Remington, H. Takabe*
9:15	704	Anomalous heating by Intense Neutrino Fluxes in Astrophysical Plasmas *L.O. Silva, R. Bingham, J.M. Dawson, W.B. Mori, and S. Dalhed*
9:30	705	CALE Simulation of the Supernova Remanant Experiment *O.A. Hurricane*
9:45	706	A Variational Principle Approach to Short-Pulse Laser Plasma Interactions in 3D *B.J. Duda and W.B. Mori*
10:00	707	Helicon sources as laser targets *F.F. Chen*
10:15		BREAK

Oral Session 8 - Ultra-Intense, Short Laser Pulse (Norreys, Chair)

10:30	801	'Frustrated' Debye shielding as an explanation of satellites to higher harmonics generated in intense laser-plasma interaction *R.S. Marjoribanks, L. Zhao, F.W. Budnik, G. Kulcsar, R. Wagner, T. Maksimchuk, D. Umstadter, P. LeBlanc, M. Downer, and R.P. Drake*
10:45	802	Observation and discussion of optical (3/2) scatter in ultra-high intensity laser-solid interactions *A.C. Machacek, D.M. Chambers, J.S. Wark, I. Watts, M. Zepf, A.E. Dangor, E. Clark, K. Krushelnick, M. Santala, M. Tatarakis, P.A. Norreys, R. Allot, C.N. Danson, D. Neely and R.S. Marjoribanks*
11:00	803	Initial experiments on the JanUSP laser at focal intensities > 10^{21} W/cm2 *P.K. Patel, J. Bonlie, F. Patterson, D.F. Price, K. Widmann, S.C. Wilks, P.T. Springer*
11:15	804	Non-paraxial propagation of ultrashot laser pulses in underdense plasma *E. Esarey, C.B. Schroeder, B.A. Shadwick, W.P. Leemans, J.S. Wurtele*
11:30	805	Interaction of Intense Laser Light with Super-Critical Density Plasma *T.J.M. Boyd and A. Dyson*
11:45	806	Experimental evidence of a fast electron jet traveling through solid targets irradiated at relavistic laser intensites *L. Gremillet, F. Amiranoff, M. Koenig, F. Pisani, G. Bonnaud, C. Lebourg, C. Rousseax, C. Toupin, A. Antonicci, D. Batani, E. Martinolli, T. Hall, P. Norreys, H. Bandulet, and H. Pepin*
12:00 PM	807	Generation of Single Cycle Laser Pulses by Photon Acceleration *F.S. Tsung, R.G. Hemker, W.B. Mori, and T. Katsouleas*

Invited Talk 3

7-8 PM	3IT	High Intensity Laser Plasma Interactions, *D. Umstadter*

8-11 PM **Poster Session 3**

3P1 The Two Plasmon Decay Instability in the Presence of Multiple Crossing Laser Beams
B.B. Afeyan, J.W. Fleischer, and A.J. Schmitt

3P2 Analysis and Simulation of Sound Waves Governed by the Ion-Fluid and Poisson Equations
M.V. Kozlov and C.J. McKinstrie

3P3 Filamentation of smoothed laser beams in hot plasmas
G. Riazuelo and G. Bonnaud

3P4 Stationary laser beam filaments in a semi-collisional plasma
V. Yu. Bychenkov and V.T. Tikhonchuk

3P5 Interaction experiments with a fiber-smoothed laser beam at $2\omega_o$ on the Phebus laser facility: massive targets and He-gas targets
C .Rousseaux, F. Amiranoff, M. Casanova, N. Renard-LeGalloudec, V. Malka, D. Mourenas, M. Rabec LeGlohaec

3P6 Theory of Thomson scattering spectra from laser produced plasmas
W. Rozmus, V. Bychenkov, S. Glenzer, K. Estabrook, H.A. Baldis, and P.E. Young

3P7 Hard X-ray Signatures for Laser-Plasma Instabilities on OMEGA
C. Stoekl, V. Yu. Glebov, D.D. Meyerhofer, W. Seka, V.A. Smalyuk and J.D. Zuegel

3P8 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, K.B. Wharton

3P9 A 3D PIC code to Study Plasma Interactions with Ultra-High Intensity Lasers
C.H. Still, A.B. Langdon, B.F. Lasinski, D.E. Hinkel, S.P. Hatchett, and S.C. Wilks

3P10 A Simple Electromagnetic Wave Solver for 1-D Hydrocodes
J.T. Larsen and M.D. Feit

3P11 Time resolved X-ray spectroscopy of thin foil heated by 100 fs, 10^{18} W/cm^2 laser pulse
R. Shepherd, P. Audebert, D. Price, K. Fournier, R. Lee, B. Young, and P. Springer

3P12 Investigation of laser-created relativistic plasma channels by ion spectroscopy
M. Hegelich, G. Pretzler, U. Schramm, D. Habs, A. Pukhov, J. Meyer-ter-Vehn and K. Witte

3P13 Neutron spectroscopy for study of ion acceleration in Ultra-Intense laser Interactions with Polarization Dependence
H. Habara, R. Kodama, N. Izumi, Y. Sentoku, K.A. Tanaka, Y. Kitagawa, K. Mima, and T. Yamanaka

3P14 Recent Advances in the Simulation of Ultrahigh Intensity Laser-Plasma Interaction
E. Lefebvre, C. Toupin, F. Walraet, G. Bonnaud and L. Gremillet

3P15 Opacity of an underdense plasma slab due to the parametric instabilities of an ultra-intense laser pulse
J.C. Adam, A. Heron, G. Laval, and P. Mora

3P16 Resonant coupling between surface and interface plasma waves in high-density sharp-edged planar or spherical plasmas produced by ultrafast laser pulses
J. Kupersztych and M. Raynaud

3P17 Observation and Interpretation of the Angular Patterns and Characteristics Energies of Relativistic Electrons Ejected from Petawatt Laser Targets
S. Hatchett, R.A. Snavely, M. Key, C. Brown, T. Cowan, G. Henry, B. Langdon, B. Lasinski, D. Pennington, M. Perry, T. Phillips, C. Sangster, M. Stoyer, and S. Wilks

3P18 Numerical Study of Linear Feed-out of Short-Wavelength, Rear-Surface Perturbations in Planar Geometry
V. Lobatchev and R. Betti

3P19 Direct drive laser-fusion pellet designs for the NIF
A.J. Schmitt, J.H. Gardner, D.G. Colombant, S.E. Bodner, and J.P. Dahlburg

3P20 Radiation Hydrodynamics Effects in Laser Irradiated Targets
V. Serlin, S.P. Obenschain, J.P. Dahlburg, A.J. Schmitt, D.E. Colombant, J.H. Gardner, and T. Lehecka

3P21 Calculations of the Pressure Tensor in 2-D Geometry in the Presence of Large Gradients and Magnetic Fields
K.G. Whitney and A.L. Velikovich

3P22 Modeling Line Emission from Dopants in ICF Pushers
S.H. Langer, H.A. Scott, M.M. Marinak, and O. Landen

3P23 Recent ICF Double-Shell Capsule Implosions Results
R.G. Watt, N.D. Delameter, S.C. Evans, P.L. Gobby and W.S. Varnum

3P24 A superconfiguration postprocessor for M-shell spectroscopy of NLTE laboratory plasmas
O. Peyrusse and F. Wagon

Friday, June 18, 1999

Oral Session 9- Indirect Drive and Laser Plasma Interactions (Barnes, Chair)

8:30 AM	**901**	High-Convergence Implosions in tetrahedral Hohlraums at OMEGA *J.M. Wallace, G.R. Bennett, N.D. Delameter, W.S. Varnum, R.G. Watt, K.A. Klare, J.A. Oertel, A.A. Hauer, T.J. Murphy, P.L. Gobby, D.C. Wilson, S.M. Pollaine, R.E. Turner, R.S. Craxton, J.D. Schnittman, F.J. Marshall, W. Seka, C. Stoeckl, V. Yu. Glebov*
8:45	**902**	High-convergence implosion studies on the Omega laser with indirectly-driven vacuum hohlraums *P. Amendt, R.E. Turner, O.L. Landen, C. Decker, S.G. Glendinning, S.W. Haan, O.S. Jones, S.M. Pollaine, L.J. Suter, and R. Wallace*
9:00	**903**	Time Resolved Symmetry Measurements using the Reemission Ball Method *G.R. Magelssen, N.D. Delameter, S. Evans, J.J. MacFarlane, N. Landen, G. Glendinning, and P. Amendt*
9:15	**904**	Diagnosis of ignition shots on NIF: how will we know what happened? *S.W. Haan, O.S. Jones, T.R. Dittrich, J.A. Koch, T.C. Sangster, and M.J. Edward*
9:30	**905**	Feasibility of High Yield/High Gain NIF capsules *L. Suter, B. VonWontergham, D. Munro, S. Haan, S. Pollaine, and M. Tabak*
9:45	**906**	Radiation Environment in Nonsymmetric NIF Hohlraums *O. Jones, L. Suter, M.M. Marinak and G.D. Kerbel*
10:00	**907**	Probing Radiation Hydrodynamics Non-uniformities Due to Joints Through Cylindrical Implosions *S.R. Goldman, C.W. Barnes, K. Klare, M. Dunne, P. Graham, B.R. Thomas*
10:15	**908**	3D PIC simulations of laser plasma interactions near quarter critical *F. S. Tsung, R. G. Hemker, C. Ren, and W. B. Mori*
10:30	**909**	Hot electrons from two-Plasmon Decay *D.A. Russell and D.F. DuBois*
10:45	**9010**	Angular dependence of $3\omega_o/2$ spectra near the two-plasmon decay threshold *P.E. Young, J.D. Moody and W. Rozmus*
11:00		Conference Ends

ORAL SESSION 1

ULTRA-INTENSE, SHORT PULSE LASER INTERACTIONS

Erik Lefebvre, Chair

Monday, June 14th, 1999

29th Anomalous Absorption Conference
13 - 18 June 1999, Asilomar, California, USA.

Thin foils heated by 100fs 10^{18} W/cm^2 laser pulse

P. Audebert*†, R. Shepherd†, D. Price†, K. Fournier†, R. Lee†, P. Springer†
**LULI, Ecole Polytechnique, Palaiseau, France*
†Lawrence Livermore National Laboratory, P.O. Box 808,Livermore,
CA 94550

The determination of the plasma parameters (T_e and N_e) are important in interpreting the physics of high energy-density matter. When heating solid matter with an ultra-short pulse laser, the plasma parameters become transient and the temporal dynamics must be measured. We have performed experiments on thin foils under well controlled conditions at the Lawrence Livermore National Laboratory Ultra-Short Pulse laser (USP) to study the temperature and density characteristics of laser heated solids. The X-ray emission was recorded using a new two crystal Von Hamos spectrometer coupled to the LLNL ultrafast streak camera. The experimental set up allowed us to recorded Heα,β and γ of aluminum as function of time for different targets and laser conditions.

To understand the experimental results, we have used the 1-D EUTERPE code to study the electron distribution for different foil thickness and at a laser solid interaction power of $I\lambda^2 = 2\ 10^{18}$ Wμm^2/cm^2. The simulation shows that the electron distribution can be approximated by a bi Maxwellian. To compare with the experiment, we have post-processed the electron distribution obtained from the PIC code with a two temperature collisional radiative model. Modeling results will be presented and compared to experiments.

29th Annual Anomalous Absorption Conference
13-18 June 1999

Electron Acceleration And Absorption In Laser Channel

Kunioki Mima

K. Mima, Y Senntoku, K. Tanaka, Y. Kitagawa, R. Kodama, T . Yamanaka

OSAKA UNIVERSITY

Abstract

It is well known that an intense laser pulse breake up into many filaments in underdense plasmas. Two dimensional PIC simulations indicate that the filaments are formed near the quater critical surfase,and electrons are strongly accelerated inside the channel,and strong magnetic fields are generated in the filaments.

Once the magnetic field is generated,electrons are accelerated in the mixed fields of laser and self-generated magnetic fields. The electron energy spectrum and the laser damping rate associating the above processes will be presented in the conference. the comparison of those theoretical results with the experimental results will also be presented.

29th Annual Anomalous Absorption Conference
13-18 June 1999

High Absorption, Large Current Generation And Transport In Ultra-intense Laser-plasma Interaction

Hartmut Ruhl

H. Ruhl, F. Cornolti, S. Hain, A. Macchi, P. Mulser, F. Pegoraro, And S. Sentoku

Theoretical Quantum Electronics (TQE)

Abstract

Intense laser radiation interacting with matter is capable of generating highly energetic plasmas with densities ranging from under-critical up to many times over-critical with respect to the laser wavelength. Due to the light pressure and collective field excitations in these plasmas electrons and ions can be accelerated leading to large electric current densities accompanied by MGauss magnetic fields. Under certain conditions magnetic channels and filaments with extensions of many wavelengths are formed. The latter tend to collimate and guide electrons far off target or enhance their range considerably in many times over-critical plasma. On the basis of 2D Vlasov and 2D/3D PIC simulations absorption, fast electron generation and transport of mass and energy in the plasma for different plasma densities, ultra-high laser intensities, and target geometries will be presented.

1. H. Ruhl, Y. Sentoku, K. Mima, K. A. Tanaka, and R. Kodama, Phys. Rev. Lett. 82, 743 (1999).

2. H. Ruhl, A. Macchi, P. Mulser, F. Cornolti, and S. Hain, Phys. Rev. Lett. 82, 2095 (1999).

3. H. Ruhl, F. Cornolti, A. Macchi, P. Mulser, and F. Pegoraro, "Large current transport in many times over-critical plasma", to be published.

Multi-megagauss Magnetic Field Generation And Ion Transport Inside Solids From Ultra-intense Laser Solid Interactions.

Eugene Clark

E.l. Clark, K. Krushelnick, F. N. Beg, M. I. K. Santala, M. Tatarakis, I. Watts, M. Zepf, A. E. Dangor, P. A. Norreys, J. R. Davies, A. Machecek, J. S. Wark, K. W. D. Ledingham, T. Mccanny, I. Spencer.

AWE plc

Abstract

Measurements of the proton emission behind a 125 micron Al target irradiated at an intensity up to 210e19 Watts per square centimeter have been made using the CPA arm of the VULCAN laser at the Rutherford Appleton Laboratory. The results indicate an angular dependence of the proton emission with energy. The protons are shown to originate from the front of the target and are bent by the magnetic field inside the target (which is in excess of 30 MG). Peak fields upto 70 MG have been predicted and proton transport through the target is demonstrated for the first time.

Abstract submission for the 29th Annual Anomalous Absorption Conference

Co-Chairs: Scott Wilks and Peter Young

Experimental Identification of "Vacuum Heating" at Femtosecond-Laser-Irradiated Metal Surfaces

Andy Rundquist, Mikal Grimes, Yun-Shik Lee, Mike Downer

Aluminum and iron targets were irradiated by intense ($I \leq 10^{15}$ W/cm^2), 120 fs laser pulses with sufficiently high contrast that the surface expanded no more than the peak electron quiver amplitude during excitation. Under these experimentally verified conditions, obliquely-incident p-polarized pulses uniquely experience anomalous absorption as high as 20%, with observed dependence on intensity ($(I\lambda^2)^{0.64}$). This extra absorption was distinguished from competing pump-induced linear mechanisms, including collisional absorption, resonance absorption, the anomalous skin effect, and sheath inverse bremsstrahlung, by fs-time-resolved reflectivity, which decoupled the laser and plasma parameters. On the other hand, the extra absorption agreed quantitatively with essential features of Brunel's "vacuum heating" [1], in which light is absorbed by drawing electrons into the vacuum and sending them back into the plasma with approximately the quiver velocity. To our knowledge, this is the first experimental identification of vacuum heating [2].
This work was supported by DoE grant DEFG03-97-ER54439 and Robert Welch Foundation grant F-1038.

1. F. Brunel, Phys. Rev. Lett. **59**, 52(1987); P. Gibbon and A. R. Bell, Phys. Rev. Lett. **68**, 1535 (1992).
2. M. K. Grimes, A. R. Rundquist, Y. S. Lee, and M. C. Downer, "Experimental identification of 'vacuum heating' at femtosecond-laser-irradiated metal surfaces," Phys. Rev. Lett., in press (1999).

Interaction Of Picoseconds Pulses With Strongly Overdense Plasmas

J.C. Adam, A. Héron
Centre de physique théorique
Ecole Polytechnique

A crucial ingredient of the fast ignitor concept is the fast electrons that are produced by the laser and that are supposed to generate the ignition spot. To day particles simulations cannot be performed at the density of the precompressed fuel, nevertheless 2D particles simulations at density of the order of hundred times the critical density can be done and one can hope to gain from them some insight in the behavior of fast electrons in the target.

One of the main difficulties of that kind of simulation are the boundary conditions for particles, that are always somewhat artificial. Our approach to this problem is to run large systems (i.e. only limited by the size of the computer) in order to delay as long as possible their unknown influence.

In the present paper we present results of simulations performed at 80 n_c with an initially sharp density profile. The laser beam has a gaussian profile in intensity in the transverse direction. The size of the system allows us to follow the interaction on the picosecond time scale. Simulations were performed for flux ranging from 10^{20} W/cm^2 up to 10^{21} W/cm^2.

Contrarly to previously published results performed at 10 n_c we find that the electrons tend to spread in a relatively wide cone of approximately 30^0 half width.

For very strong fluxes (10^{21} W/cm^2) we see a new effect of the quasi-static magnetic field : the magnetic pressure becomes larger then the kinetic pressure, allowing for a magnetic compression of the target.

Study of the interaction of ultra-intense laser pulses with solid targets on the Petawatt laser system*

A. J. Mackinnon, C. G. Brown, T. Ditmire, S. Hatchett, J. Koch, M.H.Key, J. Moody, A.A. Offenberger*, D. Pennington, M. D. Perry, M. Tsukamoto, and S.C.Wilks.

Lawrence Livermore National Laboratory, PO BOX 808, Livermore, Ca 94550.

*Dept of Electrical Engineering, University of Alberta, Edmonton, Canada

The interaction of short, ultra intense pulses with plasmas is currently of great interest to the plasma physics community. This is particularly true in connection with the possible use of an intense short laser pulse to ignite an ICF fuel capsule, the so-called fast igniter concept. When a laser pulse of extremely high peak power (10-1000TW) interacts with a solid target, copious amounts of MeV electrons and Gamma rays can be produced. In order to fully understand the factors that influence these processes it is clearly very important to characterize the laser plasma interaction. On the Petawatt laser system at LLNL optical probing and backscatter measurements have been used to investigate the interaction of Petawatt pulses (for typical conditions $\lambda = 1\mu m$, $E = 600J$ $\tau_p \sim 0.5ps$ and a focal spot diameter around $15\mu m$, $P \sim 1.2PW$ and $I \sim 3x10^{20}$ Wcm^{-2}) with plastic, gold and silicon targets. Time and space resolved interferometric images taken before, during and after the arrival of the main pulse gave useful information on the evolution of the plasma. In addition the spectrally resolved back scatter measurements showed interesting features in the 500-800nm region. Aspects of these data will be presented together with results from hydrodynamic and PIC code simul tions.

*Work 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 2

LASER-PLASMA INTERACTIONS

Sigfried Glenzer, Chair

Monday, June 14th, 1999

Simulations of OMEGA Long-Scale-Length Plasmas Representative of the Transition Portion of NIF Direct-Drive Pulses

R. S. Craxton, D. D. Meyerhofer, S. P. Regan, W. Seka, R. P. J. Town, and B. Yaakobi

LABORATORY FOR LASER ENERGETICS
University of Rochester
250 East River Road, Rochester, NY 14623-1299

Abstract

Long-scale-length plasmas have been formed on OMEGA by irradiating solid targets from one side with up to 30 laser beams. The plasmas are initially formed using the near-normal beams and are then maintained at a high temperature as they expand using the obliquely incident beams. The resultant plasma profiles provide an approximation to those predicted for NIF direct-drive targets. The plasmas can be irradiated by a separate, interaction beam with intensities well above those anticipated for the NIF in order to study plasma processes such as stimulated Brillouin (SBS) and Raman (SRS) scattering.

This presentation covers the design of these plasmas, including the selection of focal-spot diameters and beam timings and the limitations on the plasma scale lengths that can be generated. For plasmas with electron temperature typically in the 1- to 2-keV range, there is a limit on the interaction beam intensity beyond which the interaction beam perturbs the plasma. Compared with CH, carbon targets (used to change the ion-wave damping) produce plasmas that are slightly hotter but otherwise very similar hydrodynamically.

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.

Prefer Oral Session
Please place just before papery by D. D. Meyerhofer

Laser–Plasma Interactions in Plasmas Characteristic of the Direct-Drive NIF Foot-to-Main Drive Region

D. D. Meyerhofer,[1,2] R. Bahr, R. S. Craxton, S. P. Regan, W. Seka, R. Short, A. Simon, R. P. J. Town, and B Yaakobi

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[1]also Dept. of Mechanical Engineering
[2]also Dept. of Physics and Astronomy

Abstract

Direct-drive DT cryogenic targets on the NIF will be driven by an ~10-ns-duration, 40:1 intensity contrast laser pulse, consisting of an ~5-ns-long foot pulse followed by a transition to a 3-ns main drive pulse. NIF direct-drive-scale coronal plasmas are created on OMEGA by illuminating solid CH targets with up to 30 laser beams. Previous experiments have shown that the stimulated Brillouin (SBS) and Raman (SRS) scattering instabilities have extremely low levels or are not present at all in plasma conditions and with interaction beam intensities corresponding to the main drive pulse [S. Regan et al., to be published in Phys. Plasmas (1999)]. These experiments have been extended to study SBS and SRS in plasmas that have characteristics of the transition portion of the laser pulse. These plasmas are cooler (1~2 keV) and have shorter scalelengths (<0.5 mm) than those produced during the main drive pulse.

SBS and SRS are not observed at intensities that correspond to the total overlapped NIF intensity, although SBS has been observed at higher interaction beam intensities. The experimental results in CH targets will be described. It is also anticipated that SBS in pure C targets will be measured to determine the effect of multispecies plasmas versus single-species plasmas on the SBS instability.

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.

Prefer Oral Session
Please place after paper by R. S. Craxton

29th Annual Anomalous Absorption Conference
13-20 June 1999

Designs of He/H_2 filled gasbag experiments on Nova

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

L. Lours
Commissariat a l'Energie Atomique

In recent years, many experiments[1] have been performed on Nova using CH plasmas in order to evaluate backscattering instabilities for conditions similar to those expected on the Laser MegaJoule (LMJ) and the National Ignition Facility (NIF). However, it is likely that the gas fill on both NIF and LMJ will be He/H_2. There are several differences to be expected with using a He/H_2 mixture as compared to a CH plasma. This is true even for plasmas with similar densities and ion and electron temperatures. For example, the ion damping for a He/H_2 plasma is typically higher than that for a CH plasma. Recent experiments have shown the SRS reflectivity scales with ion damping[2]. NIF/LMJ like ion damping regimes have not yet been reached on Nova.

Therefore, we have designed targets that will enable us to reach NIF/LMJ like ion damping regimes on Nova. We will present 2D hydrodynamical Lasnex simulations of these targets and discuss how the results of the experiments will allow us to scale to NIF/LMJ.

1. B.J. MacGowen et al , Phys. Plasmas. 3, 2029 (1996)
2. J.C. Fernandez *et al*, Phys. Rev. Lett. 77, 2702 (1996)
   R. Kirkwood *et al*, Phys. Rev. Lett. 77, 2706 (1996)

Twenty–Ninth Annual Anomalous Absorption Conference
Asilomar Conference Center, Pacific Grove, CA
13-18 June, 1999

Measurements of SRS and SBS backscattered light from He/H_2 cryogenic Nova gasbag targets

J. D. Moody, B. J. MacGowan, C. D. Decker, S. H. Glenzer, R. K. Kirkwood, P. E. Young, R. L. Berger, G. W. Collins, C. G. Geddes, J. A. Sanchez, L. J. Suter, and E. A. Williams

Lawrence Livermore National Laboratory, Livermore, CA, 94550

We have conducted the first studies of SRS and SBS backscattered light from cryogenic He/H_2 filled gasbag targets using the Nova laser. The experiments use three separate mixtures of He and H_2 gases at 20-30 Kelvin to vary the ion Landau damping and determine the resulting effect on the backscattering instabilities. Ignition hohlraum targets for the National Ignition Facility (NIF) are presently designed to be filled with a mixture of He and H_2 gases and cooled to cryogenic temperatures (20 K). The laser-plasma instabilities (LPI) anticipated in the resulting long scalelength plasma have been studied previously using CH filled gasbag targets at room temperature. Although similar in temperature and density to the CH plasma, the He/H_2 plasma has a lower Z and higher ion damping value. The CH filled targets have shown evidence for increasing SRS with increasing ion damping [1]. The He/H_2 experiments show some similarities with the CH experiments in that the SRS and SBS levels are consistently anticorrelated both in time and in time-integrated amplitude. However, there are also differences in the scattering dependence on ion damping which we will discuss. We will also present the measurements of the SRS and SBS time resolved spectra and compare with simulations.

1. J. C. Fernandez, *et al*, Phys. Rev. Lett. **77**, 2702 (1996); R. K. Kirkwood, *et al*, Phys. Rev. Lett. **77**, 2706 (1996).

*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 adjacent to Decker and Williams.

Observed Insensitivity of Stimulated Raman Scattering on the Damping Rate of Electron Plasma Waves

Juan C. Fernández, J. A. Cobble, D. S. Montgomery and M. D. Wilke
Los Alamos National Laboratory, Los Alamos, N.M., USA

B. B. Afeyan

Polymath Research Inc., Pleasanton, Ca., USA

We have studied stimulated Raman back scattering (SRS) in Nova plasmas approaching the conditions expected within present ignition-hohlraum designs for the National Ignition Facility. We have relied for these experiments on Nova hohlraums designed to provide long-scale, nearly homogeneous plasmas. The observed Raman reflectivity is sizable even when the electron temperature is high and the electron density is low. The reflectivity is insensitive to variations in laser intensity and electron density. The density was varied systematically in order to vary the damping rate of plasma and light waves. We have calculated the damping rate of plasma waves accounting for modification of the electron velocity distribution by the laser. The Raman reflectivity is insensitive to laser intensity above the onset intensity. It is also insensitive to the reflectivity from stimulated Brillouin back scatter, which varies for the conditions in this particular data set. These data complement previous observations that the Raman reflectivity in these plasmas depends on the damping rate of ion acoustic waves, which are not directly involved in SRS [Fernández *et al.,* Phys. Rev. Lett. **77**, 2702 (1996); Kirkwood *et al.,* Phys. Rev. Lett. **77** 2706 (1996)]. All this behavior is consistent with the Langmuir (or parametric) decay instability and subsequent Langmuir turbulence being responsible for the nonlinear saturation of SRS in these NIF-relevant plasmas.

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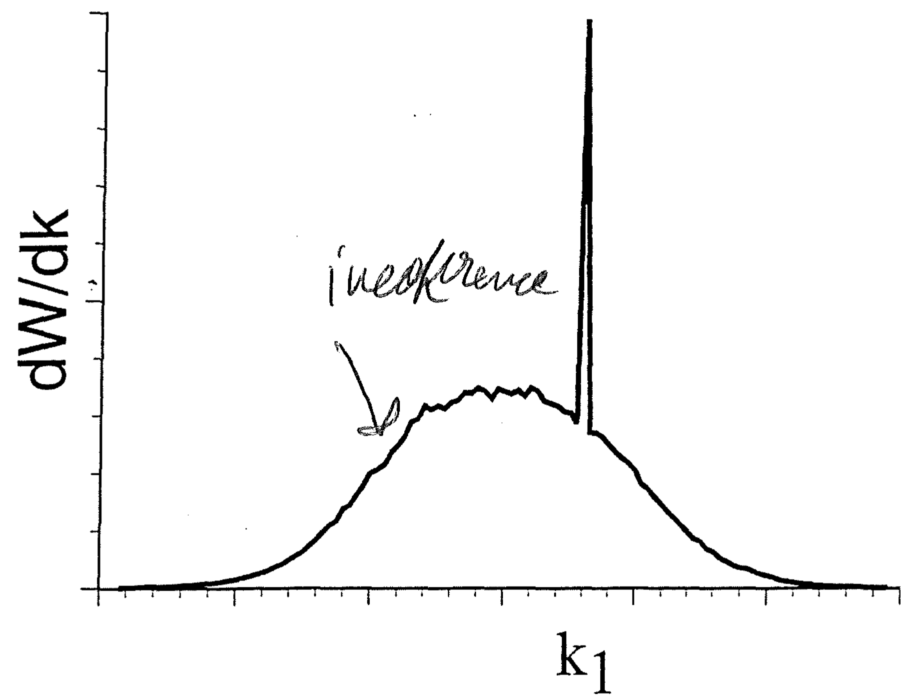
Super-thermal Self-Consistent SRS Seed*

Harvey A. Rose

Los Alamos National Laboratory

For given laser and plasma parameters, SRS spectrum and $\nu(\varepsilon)$, the Langmuir wave (LW) anomalous damping as a function of energy injection rate, ε may be self-consistently determined. Once it exceeds a threshold value, the LWs have a spatially incoherent component. The corresponding smooth part of the LW energy spectrum, dW^3/dk^3, near the primary SRS daughter LW at $\mathbf{k}_1$, is a super-thermal SRS seed.



This seed leads to a broader frequency (or equivalent density) range of scattered light than predicted by theories which only have a thermal level of incoherent LW fluctuations. An example is presented in which an otherwise negligible, gradient limited component of the SRS spectrum becomes dominant.

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* This work was performed under the auspices of the U. S. Department of Energy by the Los Alamos National Laboratory under contract No. W-7405-Eng-36

oral presentation preferred

Abstract Submitted
for the 29th Anomalous Absorption Conference, June 13-18, 1999 Meeting of
The Normalcy Deficient Society

Sorting Category: 4.1 (theoretical)

The evolution of the frequency and wavenumber of the transmitted and reflected light in 3D simulations.* R. L. BERGER, A. B. LANGDON, D. E. HINKEL, C. H. STILL, E. A. WILLIAMS, *Lawrence Livermore National Laboratory* — Using the 3D wave propagation code, F3D [1], with nonlinear models for the backscattered SBS and SRS [2], we have computed the transmitted and reflected light for laser and plasma conditions relevant to ignition hohlraums. By assumption, we are limited to near backscatter or near forward scatter. However, we find that the scattered light amplitude is strongly collimated for which paraxial approximations are valid. The frequency spectrum and the wavenumber spectrum of the transmitted and reflected light are calculated when the incident light is smoothed with random phase plates only[3], and in conjunction with smoothing by spectral dispersion[4] or 4-colors[5].

*Work performed under the auspices of the U.S. DoE by LLNL under contract No. W-7405-ENG-48.

[1]R. L. Berger et al., Phys. Fluids B 5, 2243 (1993)
[2]R. L. Berger et al., Phys. Plasmas 5, 4337(1998)
[3]Y. Kato and K. Mima, Appl Phys. Comm. 329, 186(1992)
[4]S. Skupsky, et al., J. Appl. Phys. 66, 3456(1989)
[5]D. M. Pennington, et al., ICF Quarterly 5, 130 Jan. 1995

No

Prefer Oral Session
Prefer Poster Session

Richard L. Berger
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Lawrence Livermore National Laboratory

Twenty–Ninth Annual Anomalous Absorption Conference
Asilomar Conference Center, Pacific Grove, California
13-18 June, 1999

Optical Mixing Controlled Stimulated Scattering Instabilities: Effects of a Large Amplitude Probe Beam on the Backscattering of a Pump Beam

B. B. AFEYAN[1], J. W. FLEISCHER[1], C. GEDDES[2], D. S. MONTGOMERY[3], R. KIRKWOOD,[2], K. ESTABROOK[2], A. J. SCHMITT[4] D. MEYERHOFER[5] AND R. P. J. TOWN[5]

[1]Polymath Research Inc., Pleasanton, CA
[2]Lawrence Livermore National Laboratory, Livermore, CA
[3]Los Alamos National Laboratory, Los Alamos, NM
[4]Naval Research Laboratory, Washington, DC
[5]Laboratory for Laser Energetics, Rochester, NY

We have performed a series of experiments on Omega as part of the National Laser Users Facility (NLUF) Program to study the effects of overlapping beams on the reflectivity levels of a high intensity interaction beam. We have used $10\mu m$ CH exploding foils and simultaneously monitored the time resolved Raman and Brillouin backscattering spectra of the pump as well as the transmitted properties of the probe beam. The crossing angle between pump and probe was 155 degrees. We varied the crossing point in the plasma to be at the density peak and off by $500\mu m$ to either side. The intensity ratio between probe and pump was also varied to be 1:1, 1/2:1 and 1/15:1. The correlation between the time evolution of the various instabilities will be shown as well as evidence for percent level reflectivities emanating from very low density plasmas (typically 4% of the critical density). Our analysis so far indicates that focusing the lasers nearer to the Mach -1 point, where a resonantly excited ion acoustic wave is expected, causes the most significant reduction of both the Raman and Brillouin backscattering levels (of the order of 40% and 80 %, respectively in the 1:1 probe to pump intensity ratio case) when compared to beams focused at the Mach +1 point. In addition, the crossed beam gain is more than a factor of 2.7 higher in the Mach -1 focused beam case than for the Mach +1 in the 1/15:1 probe to pump intensity ratio case.

These results indicate that backscattering data obtained from a single interaction beam may be misleading when used to predict instability levels when other high intensity beams cross it, a situation that will occur, for example, at the light entrance hole (LEH) of NIF hohlraums.

*This work is performed under the auspices of the U. S. Department of Energy under the grant DE-FG03-99SF21787. The work by LLNL employees was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-ENG-48, while that of LLE employees 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. LANL and NRL staff acknowledge the support of their respective laboratories and their DOE contracts.

PREFER ORAL SESSION

INVITED TALK 1

Short Pulse Laser Solid Interactions
by
Anthony Bell
Imperial College

Monday, June 14th, 1999
Scott Wilks, Chair

29th Annual Anomalous Absorption Conference
13-18 June 1999

Short-pulse Laser-solid Interactions (invited)

Tony Bell

Imperial College

Abstract

Advances in laser technology have led laser-plasma interactions into a completely new regime over the past few years. Laser energy is absorbed into relativistic electrons with mean free paths of the order of the target thickness. The number density of energetic electrons can be greater than the critical density, and approaching the solid density. Transport is dominated by electric and magnetic fields. Electric field can confine energetic electrons to the region of the laser spot. In other circumstances, the magnetic field can collimate the energetic electrons into a beam as they propagate through the target. The electric and magentic fields also influence the propagation of energetic ions. The generation of electric and magnetic fields is governed by the ability of the thermal background plasma to supply a return current. This gives rise to effects which were not anticipated, and which may have consequences for the Fast Igniter route to ICF.

MIXED POSTER SESSION 1

Monday, June 14th, 1999

Twenty-Ninth Annual Anomalous Absorption Conference
Pacific Grove CA
June 13-18, 1999

Backscatter and Transmitted Beam Measurements at Omega For Optical Mixing and Other Experiments*

C.G.R. Geddes[1], B.B. Afeyan[2], J.W. Fleischer[2], R.K. Kirkwood[1], D.S. Montgomery[3], D. Meyerhofer[4], W. Seka[4], K. Estabrook[1], A.J. Schmitt[5], R.P.J. Town[4], S. Alvarez[1]
[1] LLNL, [2] Polymath Research Inc., [3] LANL, [4] LLE, [5] NRL

Two new full aperture backscatter stations (FABS) / transmitted beam diagnostics (TBDs), along with near backscatter imagers (NBIs), are being installed on beams 25 and 30 at Omega. These diagnostics for the first time enable multiple cone and crossed beam experiments with the monitoring of back and/or forward scatter from two beams. Raman and Brillouin time resolved and energy integrated measurements are provided on each station.

The first FABS has been operated to measure Raman and Brillouin backscatter spectra and energies in recent experiments. Work is continuing, and the second FABS and the two NBIs will be installed shortly.

We have used the first of the FABS along with other diagnostics to study the effects of overlapping beams on the backscattering of a high intensity pump, and on the transmission of a low intensity probe beam (see also B. Afeyan, this conference). Pump and probe were crossed at 155 degrees in the plasma produced by a 10μm CH exploding foil. The ratio of probe to pump intensity and the crossing volume were varied in order to explore the resonant generation of an ion wave at the mach -1 point and its effect on backscatter and transmission.

*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 and by Polymath Research Inc. under Contract DE-FG03-99SF21787.

We request a poster session to follow the talk given by B. Afeyan.

29th Annual Anomalous Absorption Conference
Asilomar Conference Center, Pacific Grove, CA
June 13-18, 1999

Laser-plasma interaction in megajoule cavities

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Two types of laser-plasma interactions are expected to be important in megajoule cavities : (i) parametric instabilities which can develop in the gas or in the underdense gold wall inside the cavity ; (ii) laser beam crossing at the entrance of the cavity. We are studying these two kinds of processes in order to find some safety margins in the context of target design and to test our models with the available experimental data.

To estimate the risks due to the parametric instabilities, we use our post-processor PIRANAH. Simulations of megajoule cavities were performed with the 2D hydro code FCI2. Using the characteristic quantities obtained from these simulations, we computed Raman and Brillouin reflectivities and spectra for inner and outer beams. These results will be shown and the improvements to the post-processor PIRANAH will be discussed.

Laser beam crossing has been studied with several models. A basic envelope equation model which does not include parametric instabilities gives a qualitative understanding of the experimental data.[1] Taking into account the smoothing of laser beams does not seem to reduce the energy transfer. Numerical simulations have also been performed with the multi-dimensional wave-coupling code KOLIBRI.[2] We find that Brillouin scattering drastically affects the energy transfer.

1. R. K. Kirkwood *et al.*, Phys. Rev. Lett. **76**, 2065 (1996)
2. S. Hüller *et al.*, Phys. Scr. **T63**, 151 (1996)

1999 Anomalous Absorption Conference

The Competition of Stimulated Raman and Brillouin Backscatter in LULI Multiple Laser Beam Experiments

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Multiple laser beam experiments at 1 micron in exploding foils at the LULI facility exhibit an interplay of stimulated Brillouin scattering (SBS) and stimulated Raman scattering (SRS).[1] There is evidence in a series of experiments that the level of SBS can be decreased while SRS emissions are increased by increasing the laser intensity of a second beam injected at a small finite relative angle. In previously published work[2] we observed that ion wave mode coupling and ion wave parametric decay can help to partially suppress SBS in BZOHAR two-dimensional particle/fluid simulations. We have extended that work with detailed analytical and numerical modeling with a one-dimensional mode coupling analysis and with simulations performed with the multi-dimensional F3D code. We assess the roles of filamentation, secondary instabilities (e.g., Langmuir decay instability), ion wave mode coupling, and local pump depletion in hot speckles to understand SBS, SRS, and their competition in the LULI experiments. Mechanisms for the observed anti-correlation of SBS and SRS are evaluated quantitatively.

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

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[1]C. Labaune, H.A. Baldis, B.I. Cohen, W. Rozmus, S. Depierreux, E. Schifano, B.S. Bauer, and A. Michard, Nonlinear Modification of Laser-Plasma Interaction Processes Under Crossed Laser Beams Irradiation, (November, 1998), to be published in Phys. Plasmas.

[2]B.I. Cohen, B.F. Lasinski, A.B. Langdon, E.A. Williams, H.A. Baldis, and C. Labaune, Suppression of Stimulated Brillouin Scattering by Seeded Ion Wave Mode Coupling, Phys. Plasmas **5**, 3402 (1998).

Interaction of Two Crossed RPP Laser Beams with a Plasma+

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Department of Physics, University of Alberta, Edmonton, Canada
H. A. Baldis, C. Labaune*
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Lawrence Livermore National Laboratory, Livermore, USA
C. E. Capjack,
Department of Electrical Engineering, University of Alberta, Edmonton, Canada

Numerical simulations of two crossed RPP beams interacting with a plasma are carried out by means of a two-dimensional code solving non-paraxial electromagnetic and ion-acoustic wave equations [1]. Similarly to single beam simulations, non-stationary self-focusing and forward SBS are observed when the average power in a hot spot is larger than critical. These instabilities contribute to plasma smoothing of the laser beams, i.e. to spreading in angle and frequency of the forward propagating light. This plasma smoothing in turn reduces backward SBS reflectivity.

Self-smoothing of laser beams is enhanced in the crossed RPP beam geometry due to the dynamical energy exchange between the beams and to the generation of transverse density modulations by the beating of the two lasers.

Our simulations follow closely the time variation of the two equal intensity laser pulses in the LULI experiment [2]. The strongly red-shifted component in the frequency spectrum of the transmitted light has been observed. It dominates the spectrum at the time when the average laser power reaches the critical value.

We have also studied numerically the effect of different colors of a laser light on the energy exchange between RPP beams.

[1] V. V. Eliseev, W. Rozmus, V. T. Tikhonchuk, and C. E. Capjack, Phys. Plasmas **3**, 2215 (1996).
[2] C. Labaune et al., Phys. Plasmas, **6** (5) in press (1999).

* *Ecole Polytechnique and CNRS, Palaiseau, France*
+ *This work was partially supported under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48 through the Institute for Laser Science and Applications.*

Two-dimensional PIC Simulations of SBS in Multiple Laser Hot Spots

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We show results of a recently developed two-dimensional hybrid PIC code to study kinetic effects and nonlinearities in the evolution of ion acoustic waves associated with Stimulated Brillouin Scattering (SBS). The ions are treated as particles while the electrons are considered as an isothermal, adiabatic fluid. The system is closed by the Poisson equation. In order to assess the specific role of the kinetic effects as compared with the fluid nonlinearities, we carried out 2D simulations within a sub-system defined as follows: the incident laser is a smoothed beam propagating freely within the plasma; the backscattered light is prescribed at the outgoing boundary of the sub-system as a smoothed beam characterized by the average intensity corresponding to a given SBS reflectivity. The superposition of the incident and backscattered light waves gives rise to the driving ponderomotive potential. This modeling generalizes previous PIC investigations of SBS carried out for a single speckle[1] to the case of multiple laser hot spots.

The amplitudes of $\delta n_{SBS}/n$ for the SBS driven ion sound waves and of the backscattered light at the entrance boundary can be characterized as a function of the laser intensity and reflectivity. This allows firstly a comparison with the results obtained from nonlinear fluid simulations.[2] Such a comparison makes it possible to determine the regime where kinetic effects can be ignored. Secondly, it is the first part of a longer term project, employing a local-global analysis[3] so as to determine the SBS reflectivity of a full, realistic plasma.

1 B. I. Cohen, B. F. Lasinski, A. B. Langdon, and E. A. Williams, Phys. Plasmas **4**, 956 (1997).
2 See oral presentation: *Nonlinear Hydrodynamic Simulations of SBS in Laser Hot Spots*, J. Myatt, S. Hüller, D. Pesme, and C. Riconda.
3 W. Rozmus, M. Casanova, D. Pesme, A. Heron, and J.C. Adam, Phys. fluids B **4**, 576 (1992).

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29th ANNUAL ANOMALOUS ABSORPTION CONFERENCE

Ion plasma waves induced by electron oscillations

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ABSTRACT

The impact of electron oscillations on longitudinal ion waves in plasmas is discussed, with some improvements to a calculation some attendees may have seen previously. Physically, the oscillating electrons cannot shield charge fluctuations, in the direction of their oscillations, on a scale smaller than approximately the oscillation amplitude. Mathematically, a fluid derivation from fundamentals that accounts for such oscillations, and that allows them to be driven by a pump of arbitrary wavelength, reveals this effect. The frequency of ion waves can be increased from the ion acoustic frequency to the ion plasma frequency in the presence of large enough oscillations. Because of their increased phase velocity, such ion plasma waves will be weakly damped. The impact of the inherent coupling to other unstable modes will be considered.

This work complements, and will be compared to, prior work using kinetic theory to treat the case of a dipole (spatially invariant) pump. The new work may apply to two situations in which the finite pump wavelength is essential. The first is the observation of satellites at approximately the ion plasma frequency in data from short-pulse laser experiments. The second is the quenching of stimulated Brillouin scattering by stimulated Raman scattering. These two cases will be discussed.

RPD acknowledges support from the U.S. Department of Energy and the University of Michigan. RSM acknowledges support from the Natural Science and Engineering Research Council of Canada.

29th Annual Anomalous Absorption Conference
13-18 June, 1999

The Effect Of Kinetic Processes On Parametrically Excited Langmuir Turbulence

K. Y. Sanbonmatsu, H. X. Vu, D. F. Dubois, B. Bezzerides
Los Alamos National Laboratory

We use reduced-description particle-in-cell (RPIC), quasilinear-Zakharov (QLZ) and hybrid (RPIC ions and QLZ electrons) models to examine the effect of kinetic processes on parametrically excited Langmuir turbulence. The RPIC method has particle electrons, particle ions and reduced numerical dissipation and ion noise levels.
The QLZ model accounts for electron heating in the Landau damping rate by coupling the quasilinear diffusion equation to the Zakharov equations.
We study the influence of kinetic effects on the electron and ion distributions, and on the spectral shape and level of Langmuir and ion acoustic waves for the cases of Langmuir collapse and Langmuir decay instability cascade driven by a spatially uniform electromagnetic pump.
We have found that many kinetic processes effect these instabilities. Quasilinear diffusion of electrons increases the electron Landau damping rate, lowering the Langmuir wave saturation levels. Ion trapping may cause a significant shift in the ion acoustic spectrum. Advective effects may change the level of Langmuir waves at low wave number. We also attempt to distinguish between collapse and electron trapping signatures in electron phase space.

LA-UR-99-1663

Abstract for 29th Annual Anomalous Absorption Conference
Asilomar Conference Center, Pacific Grove CA June 13-18, 1999

Direct Drive Cylindrical Implosions on the OMEGA Laser

Cris W. Barnes, D. L. Tubbs, S. H. Batha, J. B. Beck, R. D. Day, N. D. Delamater, N. M. Hoffman, P. Gobby, J. A. Oertel, J. M. Scott, N. A. Shambo, R. G. Watt
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Laboratory for Laser Energetics, University of Rochester, Rochester, NY

A. M. Dunne, S. Rothman, D. L. Youngs
Atomic Weapons Establishment, Aldermaston, UK

D. Haynes, C. Hooper
University of Florida, Gainesville, FL

Studies of hydrodynamic instabilities in convergent geometry are continuing in the series of direct drive cylindrical implosions on the OMEGA laser at the Laboratory for Laser Energetics of the University of Rochester.[1,2,3] Current work concentrates on understanding and ameliorating the effects of short-wavelength nonuniformities from both the laser and the target surface roughness on the perturbation growth; measuring the "thermodynamics" of the cylindrical implosions by spectroscopic[4] or neutronic methods for comparison to the observed hydrodynamics; and observing mix[5] and defect evolution at the inside interface of the ablator. Detailed tests of the accuracy of radiographic reconstruction are also performed using x-ray radiography of static targets. Results from the last year's campaigns will be presented and discussed.

This work was performed under the auspices of the U. S. Department of Energy for the Los Alamos National Laboratory under contract No. W-7405-Eng-36.

POSTER SESSION PREFERRED.

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[1] David L. Tubbs *et al.*, "Direct Drive Cylindrical Implosion Experiments: Simulation and Data," *Lasers and Particle Beams* (1999, in press).
[2] Cris W. Barnes *et al.*, *Rev. Sci. Instrum.* **70** (1999) 471.
[3] David L. Tubbs *et al.*, "Cylindrical implosion experiments using laser direct drive," *Physics of Plasmas* (1999, in press).
[4] D. A. Haynes *et al.*, "Cl K-Shell spectroscopy of directly driven cylindrical implosions," *J. Quant. Spectrosc. Rad. Transfer*, (1999, in press).
[5] Cris W. Barnes *et al.*, "Observation of Compressible Plasma Mix in Cylindrically Convergent Implosion," submitted to the 7th International Workshop on the Physics of Compressible Turbulent Mixing, St. Petersburg, Russia, July 5-9, 1999.

Computations of Megabar Pressure Waves through Low Density Foams Filled with Liquid Deuterium*

Jill P. Dahlburg, John D. Sethian, Victor Serlin,
Denis Colombant
Plasma Physics Division, Naval Research Laboratory, Washington, DC

John H. Gardner
LCP&FD, Naval Research Laboratory, Washington, DC

Marcel Klapisch
ARTEP, INC, Columbia, MD

We have performed simulations of low density foam targets, evacuated or filled with liquid deuterium, that have been irradiated by the NRL Nike KrF laser at laser intensities from 2×10^{13} to 1×10^{14} W/cm^2. The simulations provide predictions for the resulting megabar pressure waves that are generated in these targets, target acceleration time histories, and the times that the shocks break out of the rear surface of the targets. These results will be quantitatively compared with data obtained from a series of experiments that were performed by Sethian.[1] Our simulation tool, FAST, is a multidimensional hydrodynamics code with multigroup radiation transport. The code includes FCT advection, classical Spitzer-Harm electron thermal conduction, inverse bremsstrahlung laser deposition, a table look-up equation of state, and opacities supplied by the NRL-STA code.

Work supported by USDoE and USONR.

[1]J. D. Sethian *et al.*, APS/DPP Meeting, (Nov., 1997).

Poster presentation preferred.

Modeling of CH Plastic Targets Coated with Thin Gold Layers

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Marchel Klapisch
ARTEP, Inc., Colombia MD.

We present the results from modeling a series of experiments where a thin gold layer (100Å-400Å) is applied over a thick (~40-60 μm) CH plastic target. These experiment had a relatively long (~3-4ns) low intensity (~ $3\text{-}5\times10^{12}$ W/cm^2) foot. We are interested in determining whether a thin solid overcoat mitigates the effects of laser imprinting during the foot of the pulse. These experiments also provide a rather sensitive test for the radiation hydrodynamics used in our code.

The simulations were preformed using the NRL FAST radiation hydrodynamics code. This code solves the two temperature (electron/ion) fluid equations using an Eulerian grid that models fluid instabilities well into the nonlinear regime. Multiple materials are treated with a novel partial fraction technique that keeps the materials well separated even when interfaces are highly distorted. The code includes classical Spitzer-Harm electron thermal conduction, inverse bremsstrahlung laser deposition, a table look-up equation of state, and a non-LTE (Busquet model) multigroup radiation diffusion package with opacities supplied by the NRL-STA code.

One and two dimensional simulations will be presented which show the effect of the gold overcoat on the laser absorption and plasma scalelength. Two dimensional simulations indicate that for sufficiently thin gold layers, the gold layer may be subject to Rayleigh-Taylor (RT) instability as it is accelerated away from the ablation surface. Results will be compared with ongoing

Poster presentation preferred

29th Annual Anomalous Absorption Conference

Hydrodynamic Simulations of Static and Dynamic Laser Imprint

Y. Srebro [1,2], D. Oron [1], D. Shvarts [1,2], T. R. Boehly [3], V. N. Goncharov [3], O. Gotchev [3], V. A. Smalyuk [3], S. Skupsky [3] and D. D. Meyerhofer [3].

1. Nuclear Research Center - Negev, Beer-Sheva, Israel.
2. Ben-Gurion University Beer-Sheva, Israel.
3. Laboratory for Laser Energetics, University of Rochester, Rochester, N.Y.

The equivalent mass perturbation of static (DPP) and dynamic (SSD) laser nonuniformities is studied as a function of perturbation wavelength, laser intensity and pulse shape. The most significant parameter in determining the laser imprint has been found to be the decoupling time, the time it takes to establish a smoothing corona between the laser energy deposition region and the ablation front. This time is determined by the perturbation wavelength and by the corona formation rate, i.e. the ablation velocity, which depends on the laser pulse shape. Due to the linear dependence of the decoupling time on the perturbation wavelength, the static imprint efficiency also depends linearly on the perturbation wavelength. Hence, the initial mass modulations in the target have a different spectral composition than that of the nonuniformities in the laser radiation. Since imprinting mostly occurs only up to the decoupling time, it is important for temporal smoothing techniques to smooth laser nonuniformities before the decoupling time for each perturbationwavelength.

The relation between the hydrodynamic decoupling time and the optical sweeping rate for each wavelength determines the ultimate smoothing efficiency. For SSD smoothing, the decoupling time is proportional to the perturbation wavelength and similarly, the number of perturbation cycles swept through during a given time is inversely proportional to the wavelength. As a result the smoothing efficiency is nearly wavelength independent.

We present numerical simulations to support this simple reasoning and compare the results with imprint experiments carried out on the Omega laser using various laser smoothing techniques and pulse shapes.

29th Annual Anomalous Absorption Conference

The Effect Of Interference On The Uniformity Of Energy Deposition In Laser Driven Implosions

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Department of Physics
Dhahran, Saudi Arabia

A crucial issue for the attainment of fusion by inertial confinement method is the uniformity of energy deposition on the pellet surface. Calculations have been done to study the effect of interference between the incident and reflected laser light on the uniformity of energy deposition in laser produced plasma of a spherical target. The equations for the ray trajectory , the energy deposition along the ray and phase shift are derived under the approximation of geometrical optics. Using a ray tracing computer code surface plots of the absorbed energy density and the energy deposition per solid angle is plotted for various laser and target conditions with and without interference. It is found that the effect of interference is particularly significant during the early times of the laser pulse and is found to be reduced by using short wavelength laser.

Kinetic-Theory Foundations and Radiation-Hydrodynamics Approaches to Laser-Matter Interactions

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Radiation-hydrodynamics approaches to laser-matter interactions are reviewed. Particular emphasis has been given to the connection with the more fundamental single-particle and many-body kinetic-theory foundations, from which the reduced hydrodynamics descriptions can be systematically introduced. Alternative approaches to the electron heat conduction and radiation transport problems are discussed. Inadequacies encountered in simple transport models can be circumvented only by the adoption of a more fundamental, but more difficult, kinetic-theory description. In the accurate description of the energy exchange between matter and electromagnetic radiation, it is necessary to take into account both the laser deposition and plasma radiation processes. A particularly challenging problem is encountered in the detailed treatment of non-equilibrium charged-particle and radiation-field distributions, for which it is often necessary to provide a realistic description of the influence of the multitude of elementary collisional and radiative transitions involving bound and autoionizing states of partially ionized, many-electron atomic systems. These complex atomic processes must be systematically and self-consistently taken into account in the atomic-state and plasma-electron kinetics and in the absorption and emission of electromagnetic radiation.

This work has been supported by the Department of Energy, under contract DE-AI02-93-ER54198 to the Naval Research Laboratory, and by the Office of Naval Research.

Abstract submitted for the 29th Annual Anomalous Absorption Conference, Asilomar, CA
LAUR-99-1661

Time Resolved Symmetry Measurements using Reemission Technique in Scale-3 Hohlraums at Omega

N. D. Delamater, G.R. Magelssen, S. Evans, *Los Alamos National Laboratory, Los Alamos, NM*, J. J. MacFarlane, *PRISM Computational Sciences, Madison, WI*, N. Landen, P. Amendt, D. Bradley and G. Glendinning, *Lawrence Livermore National Laboratory, Livermore, CA.*

An important unresolved issue in NIF symmetry planning is the effect of higher order modes of asymmetry (P6,P8) on an imploding capsule. In an attempt to measure these higher order modes in NIF-like conditions, we have performed reemission ball experiments at the Omega laser using scale-3 NIF-like cylindrical hohlraums using multiple beam cones with a pulse shape simulating NIF foot conditions. The experiment used a bismuth coated plastic shell about 1200 microns in diameter centered in an 8mm long gold hohlraum. The laser pulse shape simulating the NIF foot was a 7ns square pulse with about 11 kJ of energy. This produced an effective hohlraum temperature of 70 eV. The reemission was observed using a gated imager with peak spectral response at 2 keV. We compare the measurements with simulated images calculated using both viewfactor techniques and post-processed hydrodynamic calculations. We present preliminary results from the first set of these experiments along with an analysis of the sensitivity of this technique for NIF conditions and a discussion of suitability of this technique for NIF symmetry measurements and the problems associated with measuring higher order modes like P6,P8.

Work performed under the auspices of the US DOE. under contract no. W-7405-ENG-36

* *poster session preferred*

NIF ignition capsules with high Z pushers

D. C. Wilson and P. A. Bradley
Los Alamos National Laboratory

An ignition capsule similar to the 330 eV beryllium capsule [1] (radii of 870, 950, 1105mm with 0.5 mg/cc DT gas, 0.25 g/cc DT ice, and 1.84 g/cc copper doped beryllium) can be designed by replacing the payload of unablated beryllium by the equivalent mass of high Z material. Since the radiation field is excluded from the DT fuel by the high Z shell, the copper dopant is no longer needed and pure beryllium can be used as an ablator. However if the high z shell is tungsten, then the layer is only about 1 μm thick. As the thickness of the high Z shell is increased (and the payload mass increased) the implosion velocity decreases, until at a thickness of ~9 μm an ignition threshold is reached. At this thickness the extra tamping by the high Z shell has increased the DT yield from 17 to 34 MJ. The capsule radiates 3.9 MJ of this yield as X-rays.

1 D. C. Wilson et al., "The development and advantages of beryllium capsules for the National Ignition Facility", Physics of Plasmas, **5**, p. 1953 (1998)

Prefer Poster Presentation

Anomalous Abstract
Steve Pollaine, David Bradley, Otto Landen, Russ Wallace, Ogden Jones, Peter Amendt, Gail Glendinning, Robert Turner, and Larry Suter

P6 and P8 modes in NIF hohlraums

We are now running an experimental campaign on the OMEGA laser at LLE, Rochester, to detect and correct P6 and P8 flux asymmetry inside scale-3 vacuum hohlraums that approximate the conditions of a NIF hohlraum during the foot of the NIF drive. We use a point-projection backlighter to illuminate a thin CHGe shell at two separate times, and measure the distance traveled by the shell as a function of angle. The image is detected by a microchannel plate with a magnification of 5 and a resolution of 30 microns. This gives a theoretical edge detection accuracy of about 2 microns, which is capable of seeing a 1% P6 or P8 flux asymmetry. We compare the flux asymmetry for both 3 mm and 2.5 mm diameter thin shells, and with the asymmetry detected by foam balls.

Prefer Oral talk Mon, Tue or Wed.

Abstract submitted to the 29th Anomalous Absorption Conference

MODELING RADIATION DRIVE IN HALF-HOHLRAUM GEOMETRY.*

B. F. Lasinski, L. J. Suter, K. S. Budil, C. A. Back, S. G. Glendinning, R. E. Turner, J. Edwards, J. D. Bauer, and A. S. Wan

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The half-hohlraum geometry is an interesting target for hydrodynamic instability[1] and radiation transport experiments.[2] Measurements of the radiation flux through both the laser entrance hole and the opposing constrains the modeling.[3] These targets are axisymmetic and thus an entire experiment is more easily modeled by codes such as LASNEX. Such targets have been fielded on both NOVA and Omega with a variety of laser pulse shapes. Here we describe the modeling of the radiation drive in these targets and present comparisons with experiment.

* 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] J. Edwards *et al*, "Ablative Rayleigh-Taylor Instability in Indirectly Driven Thin Aluminum Foils," presented at this conference; J. Edwards et al, "A Plasma Piston for Radiation Hydrodynamics Experiments," presented at this conference.

[2] C. A. Back *et al*, B. A. P. S. 43, 1738 (1998).

[3] C. Decker *et al*, Phys. Rev. Lett. **79**, 1491 (1997).

Development of a δf Scheme for Studying Transport of Nonthermal Particles

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Methods have been partly developed to apply the δf algorithm for computing the evolution of near-Maxwellian distributions over transport time-scales. These include the simultaneous evolution of the intrinsically kinetic component δf of the distribution using marker particles and of fluid equations for the parameters of the shifted Maxwellian background f_{SM}. Such a hybrid fluid-kinetic approach had already been tested for model problems in homogeneous plasmas [1]. A first solution we proposed to the problem of marker particle weight spreading [2] in a collisional δf algorithm has been further improved. Also, a practical procedure of sinks and sources has been implemented for maintaining marker particles in regions of velocity space where δf requires high resolution. We shall mainly focus on the progress done in applying these methods to spatially inhomogeneous plasmas. To start, a high Z plasma is considered and spatial variations are assumed one-dimensional and their amplitude small. The assumption of small perturbations will enable (1) to avoid having to evolve the background at first, so that one can concentrate on the problem of computing the self-consistent electric fields that will arise for maintaining return currents, ensuring quasineutrality, and (2) benchmarking our results against previous numerical solutions of linearized electron transport equations obtained for all regimes of collisionality [3, 4].

[1] ``Developing a Collisional δf Scheme with Evolving Background for Transport Time Scale Simulations," 3rd International Workshop on Laser Plasma Interaction Physics, Banff, Alberta, Canada (February 1999), work to be submitted for publication.

[2] Y.Chen and R.B.White, Phys. Plasmas 4, 3591 (1997).

[3] A. V. Brantov, V. Yu. Bychenkov, V. T. Tikhonchuk, and W. Rozmus, Phys.Plasmas 5, 2742, (1998).

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Two Dimensional Hybrid δf Code Development

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A previously developed[1] one-dimensional model for the study of acoustic phenomena in collisionless, laser-driven plasma has been extended to 2 dimensions. The plasma model consists of inertialess fluid electrons and fully nonlinear kinetic ions, evolved through the δf method. The electromagnetic vector potential, taken perpendicular to the plane of the simulation, is evolved by removing the rapid time variation at the laser frequency and solving for the slowly varying amplitude. The code can be used in either singly- or doubly-periodic geometry. Initial results, including benchmarks against full PIC calculations, will be presented.

[1] E. J. Valeo, J. A. Krommes, and P. W. Rambo, 40th Annual Meeting of the Division of Plasma Physics, Nov. 16-20, 1998, New Orleans, Louisiana, paper J5Q12.

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Modified electron distribution function due to inverse bremsstrahlung absorption and nonlocal transport.

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Preliminary results of studies involving analytical solutions to kinetic equation and particle-in-cell (PIC) simulations of transport processes in laser produced plasmas are reported.

We have found analytically solution to the nonlinear kinetic equation describing inverse bremsstrahlung (IB) absorption in the presence of electron-electron (e-e) collisions for the arbitrary values of the parameter Zv_E^2/v_{th}^2. For times longer than the e-e collision time the electron distribution function evolves into the distribution which has Maxwellian tails with the renormalized temperature and the characteristic flat top in the low velocity regime as it was found before by Langdon [1]. This distribution function provides a description of plasma background conditions for the linear nonlocal transport theory.

We have also addressed the problem of nonlocal heat transport and influence of acoustic fluctuations, driven by return currents, on the transport processes using PIC simulations. As a first step we consider the growth and saturation of current driven acoustic instabilities using 2D electrostatic PIC simulation model including electrons and ions. The simulations are highly efficient and parallelized allowing for long time scale simulations with a large number of particles.

[1] A. B. Langdon, Phys. Rev. Lett., **44**, 575, 1980.

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29th Annual Anomalous Absorption Conference
June 13-18, 1999
Pacific Grove, CA

A Tractable Model For Non-Local Electron Heat Transport In 2 Or 3 Dimensions Hydrodynamic Codes

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CEA/DIF

We introduce a 2 or 3 dimensions delocalization kernel for processing nonlocal heat conduction in hydrodynamics codes used for laser-produced plasmas. Some magnetic field effects can also be taken into account. First tests will be presented.

29th Annual Anomalous Absorption Conference,
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Table Top Transient Collisional X-ray Lasers

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X-ray lasers are one of the examples of physics applications which have been substantially favored from recent progress of high-power lasers. At LLNL we are performing numerical and experimental research on table-top X-ray lasers based on the transient collisional excitation scheme. On-going experiments utilize the 15TW COMET laser facility which is capable of delivering up to 5-10J in 500fs pulses on target. During the last several years this new scheme has reinvigorated research on X-ray lasers with wavelengths 120-300 Å to achieve substantially more compact size, very high gain coefficients > 60 cm-1 and high efficiency.

The progress, trends and major differences of this modern approach in X-ray laser design to the previous one will be outlined. Recent computational and experimental results with different kinds of ions, driven up to saturation intensity will be presented. Lasing parameters determined by imaging technique, laser length variation and spectroscopic methods have been compared with the numerical modeling. This research will lead to development of variety of X-ray lasers with specific characteristics required for different applications.

This work was performed under the auspices of the US Department of Energy by the Lawrence Livermore National Laboratory under Contract No W-7405-Eng-48.

Tertiary Neutron Diagnostic by Carbon Activation

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Abstract

Measurement of the yield of tertiary neutrons with energies greater than 20 MeV has been proposed as a method to determine the ρR of ICF targets. Carbon has been chosen as an activation material because of its high reaction threshold and the availability of high-purity samples.

The (n, $2n$) reaction in ^{12}C has a threshold of about 19 MeV. The product of this reaction, ^{11}C, has a half-life of 20.3 min and emits a positron, resulting in the production of two 511-keV gamma rays upon annihilation. The positron decay of ^{11}C is identical to that in the copper activation that is used as a measure of 14.1-MeV primary DT yields; therefore, the present copper-activation gamma-detection system can be used to detect the tertiary-produced carbon activation.

The current status of carbon-activation diagnostic development at LLE will be presented together with experimental results and theoretical interpretation of several direct-drive implosion experiments with carbon activation diagnostic on OMEGA.

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Prefer Poster Session

29th Annual Absorption Conference
June 13-18, 1999

Requirements for NIF's soft-xray drive diagnostic

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3- CEA, Bruyere-le-Chatel, France

For three decades soft xray measurements have been used to characterize the hohlraum radiation environment at ICF facilities worldwide. At this poster we present the requirements for NIF's soft x-ray drive diagnostic which resulted from discussions at the NIF diagnostic workshop held in early March, 1999. We present supporting information that justify the specifications and discuss possible technical approaches to satisfying those requirements.

This work performed under the auspicies of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.

29th Annual Anomalous Absorption Conference
13-18 June 1999

Time- And Space-resolved X-ray Spectroscopy For Investigation Of Fusion Pellet Implosion

Yoshihiro Ochi

Y. Ochi, K. Fujita, H. Nishimura, M. Fukao, I. Niki, T. Kawamura, A. Sunahara, M. Heya, H. Shiraga, N. Miyanaga, H. Azechi, H. Takabe, K. Mima, T. Yamanaka, S. Nakai, R. Butzbach, I. Uschmann, E. Foerster

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Abstract

Fusion pellet implosion by direct laser irradiation was investigated by means of time- and space-resolved x-ray spectroscopic measurements. Fusion pellets filled with a deuterium fuel gas including a small amount of Ar dopant were irradiated with twelve beams of intense partially coherent light and line emissions from the dopant were observed. There were two types of implosion studies. First, experimental conditions were carefully chosen to provide implosions that were as stable as possible, these we refer to as the "balanced" case. Second, the energy balance was manipulated so that two specific beams, diametrically opposed to each other, had relative energy differences. This imposes additional low-modal non-uniformity on the pellet, and these experiments are called "unbalanced" cases. Experimental results were compared with hydrocode simulations, which were post-processed by the aid of x-ray spectrum analysis code. The experimental results in terms of temporal variations of the Ar He-beta line and their spatial profiles obtained with an x-ray framing monochromatic imager were well replicated by one dimensional (1-D) simulation for the balanced case, whereas those for the unbalanced case showed large discrepancies. Furthermore, a clear difference was found in the emission of Li-like satellite lines between two cases: In the unbalanced case, the satellite lines became much more intense than the He-beta line at late time in the implosion. These experimental results may suggest that the imposed low-modal non-uniformities assisted in the quenching of hot, compressed core formation, particularly at the fuel-pusher contact surface. Spectroscopic analysis combined with hydrocode simulations will be discussed to validate this hypothesis.

ORAL SESSION 3

Physics of Direct Drive

Kunioko Mima, Chair

Tuesday, June 15th, 1999

Planar Burnthrough Experiments on OMEGA and NIKE

S. P. Regan, J. A. Delettrez, T. R. Boehly, D. K. Bradley,[1] J. P. Knauer, D. D. Meyerhofer, and C. Stoeckl

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S. Obenschain, T. Lehecka, C. Pawley, Y. Aglitskiy, V. Serlin, J. Gardner
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Abstract

Planar burnthrough [1] experiments were performed on the OMEGA and NIKE laser systems to relate the onset of the characteristic line emission from a signature layer buried under a plastic ablator to the Rayleigh–Taylor (RT) instability growth of imprinted and preimposed modes. CH/CHSi and CH/CHSi/parylene planar-foil targets were irradiated with three types of laser pulse shapes having peak intensities of 1 to 2 ∞ 10^{14} W/cm^2: a 1-ns ramp to a 2-ns flat-top, a 3.5-ns foot to a 4-ns flat-top with a 40:1 intensity contrast, and a 2-ns foot to a 4-ns flat-top with a 10:1 intensity contrast. Time-resolved x-ray spectroscopy was used to determine the onset of the Si *K*-shell emission. The burnthrough event was also imaged in Si He_a emission on NIKE with a crystal imager coupled to a framing camera detector having a temporal resolution of 200 ps. The effects of ablator thickness (8 to 14 μm), the preimposed surface mass modulations (1 = 20 μm with $a_{p\text{-}v}$ = 0.1 μm, 1 = 30 μm with $a_{p\text{-}v}$ = 0.25 mm, 1 = 60 μm with $a_{p\text{-}v}$ = 0.5 μm), the overall target thickness (20 mm, 40 mm, and 100 mm), and laser imprint on burnthrough were investigated. The burnthrough time was observed to be independent of ablator thickness in targets that were accelerated with laser pulses having a foot, while targets accelerated with a ramp to flat pulse had a burnthrough time proportional to the ablator thickness. The presence of preimposed surface mass modulations on the target did not affect the measured burnthrough time. The burnthrough time was observed to increase with increasing overall target thickness. When the laser nonuniformity was increased, the burnthrough was observed to occur earlier. The burnthrough experiments are also compared with through-target x-ray radiography.

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. 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).

Prefer Oral Session
Place before paper by J. A. Delettrez

Analysis of Planar Burnthrough Experiments on OMEGA and NIKE

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Abstract

Hydrodynamic instability growth in planar targets is studied using the 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. In spherical experiments [1] this technique has been shown to be a sensitive indicator of instability growth and, hence, of incident drive nonuniformity. We present results of the simulations of experiments carried out on planar targets with the 30-kJ OMEGA laser system and the NIKE laser system at the Naval Research Laboratory. In contrast to the experiments on OMEGA, which show an increase in the burnthrough time with ablator thickness, experiments on NIKE show very little variation of the burnthrough time with the ablator thickness. This difference may be due to the difference in pulse shape in the two sets of experiments: The NIKE pulse consists of a long (~ 3.5 ns), low-intensity foot followed by a 4-ns main flat-top pulse; the OMEGA pulse used in the burnthrough experiments consists of a 1-ns ramp followed by a 2-ns flat-top. These results are analyzed with a post-processor to the 1-D hydrodynamic code *LILAC*. If available, 2-D simulation results will also be presented to elucidate the mechanisms that lead to the early burnthrough times.

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. 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).

Prefer Oral Session
Place after paper by S. P. Regan

Simulation of the Radiative Preheat of Target Foils and Shells in Laser-Driven Ablation and Implosion Experiments

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Abstract

The hydrodynamic stability of laser-driven polymer foils and imploding polymer shells is expected to improve when radiative preheat occurs ahead of the ablation front before the target starts to accelerate. This preheat, produced by radiation from various additives in the hot corona, is simulated in one dimension to assess the dependence of the stability of accelerating shells and foils on additive composition and target configuration. To model radiation transport within the constraints on spectral resolution and atomic-model complexity imposed by computational efficiency requirements, non-LTE tables of opacity, emissivity, and ionization based on atomic physics in collisional-radiative equilibrium have been introduced. The effect of radiative preheat on the stability of the accelerating target is evaluated by calculating the growth of surface perturbations using a saturable linear multimode perturbation model of the Rayleigh–Taylor instability. The assumption of collisional-radiative equilibrium provides a more direct estimate of non-LTE opacity and emissivity than the alternative method of using LTE opacity evaluated at an effective ionization temperature and an emissivity obtained from this opacity using an approximate, empirical source function. The spectral energy resolution required for quantitative transport calculations, including fine resolution for line transport, is realized with as small a number of energy groups as possible.

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Prefer oral session

X-ray imaging diagnostics for the inertial confinement fusion experiments.

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We report on our continued development of the advanced x-ray plasma diagnostics based on spherically curved crystals. The diagnostics include x-ray spectroscopy with 1D spatial resolution, 2D monochromatic self-imaging and backlighting and can be extended to the x-ray collimating and 2D absorption and emission spectroscopy. The system is currently used, but not limited to diagnostics of the targets ablatively accelerated by the NRL Nike KrF laser.

A spherically curved quartz crystal (2d=6.68703 è, R=200 mm) has been used to produce monochromatic backlit images with the He-like Si resonance line (1865 eV) as the source of radiation. The spatial resolution of the X-ray optical system is 1.7 μm in selected places and 2-3 μm over a larger area. Another quartz crystal (2d=8.5099 è, R=200mm) with the H-like Mg resonance line (1473 eV) has been used for backlit imaging with higher contrast. Spherically curved mica (2d=9.969 è in the second order of reflection, R=200mm) has been used for backlighting of the low density foam cryotargets with the backlighter energy of 1.26 keV.

Time resolution is obtained with the help of a four-strip x-ray framing camera. Time resolved, 20x magnified, backlit monochromatic images of CH planar targets driven by the Nike facility have been obtained with spatial resolution of 2.5 μm in selected places and 5 μm over the focal spot of the Nike laser.

A second crystal with a separate backlighter has been recently added to the imaging system. This makes it possible to use of all four strips of the framing camera. As a result we have

Modeling of Laser Imprint for OMEGA and NIF Capsules

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Abstract

In direct-drive inertial confinement fusion, irradiation nonuniformities generate modulations in ablation pressure leading to perturbation growth in the imploding target. Such perturbations ("imprint"), multiplied by the ablative Rayleigh–Taylor (RT) and Bell–Plesset (BP) instabilities, could degrade symmetry of the implosion and impede ignition. The results of analytical and numerical models of laser imprint for OMEGA and NIF capsules with different ablator materials are presented. It is shown that the ablation-front perturbations have an oscillatory behavior (in agreement with results of Refs. 1 and 2) during the first shock-transit time after a sufficiently large plasma atmosphere is formed and pressure modulations are reduced by thermal smoothing ("cloudy-day" effect) and the dynamic overpressure created by thermal conduction in the blowoff region [1]. General scaling laws of the period and amplitude of oscillations are given for different target materials. It is demonstrated that using the 2-D SSD smoothing technique with the 1-THz bandwidth and performing an additional optimization in the oscillation phase of the most destructive modes, the cryogenic OMEGA and NIF shells remain intact during the implosion.

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[2] A. L. Velikovich, Phys. Plasmas **5**, 1492 (1998).

Prefer Oral Session

The fully developed stage of Radiative Plasma structures

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J.P. Dahlburg, D. G. Colombant , *Plasma Physics Division, Naval Research Laboratory*
J. H. Gardner,
L. Phillips, *LCP&FD Naval Research Laboratory* ,N. Metzler, *Physics Department NRCN, Israel and S.A.I.C McLean Va.*

avoid RPS by "tapered density" - profile of target.

The phenomenon of propagating peaked radiative plasma structures (RPS) in laser driven ablating plasmas was first seen in simulations of KrF laser interacting with a plastic target[1] and recently was also observed in experiments[2]. These density structures can strongly modify the coupling of the laser light to a direct drive fusion target. In [3], the RPS was shown to be a result of a bottleneck in the energy flow mediated by emission and absorption and transport of radiation. A model for its onset was presented.

foam can be used.

In the present talk the fully developed stage of RPS will be analyzed. We will show that, mass and momentum conservation require that, as it propagates, the density and pressure of RPS must grow with the same exponent, keeping its temperature constant. This explains simulation results of reference [1]. The case of zero exponents (i.e. steady state of a traveling wave) will be analyzed in details and compared with simulations.

Work partially supported by the U.S. Department of Energy.

[1] J.P. Dahlburg et. al. J.Q.S.R.T. **54**, 113 (1995).
[2]S.P. Obenschain et.al. BAPS (1998)
[3]G. Hazak et.al. BAPS (1998)

Reduction of Mass Perturbation Seeds in Direct-Drive Laser Targets Using Tailored Density Profiles

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Radial tailoring of initial density profiles in laser targets inverts the acceleration of the ablation front at early time [1]. This makes the mass perturbations near it oscillate at a higher frequency and at a lower amplitude than they normally would due to the "rocket effect" caused by mass ablation [2]. For planar geometry, we have previously demonstrated analytically and numerically that density tailoring can reduce the seed for the exponential RT instability growth generated by a given lateral non-uniformity in the laser drive in a target of given mass and thickness [1]. Here we discuss the efficiency of this stabilization method for a spherical geometry, under realistic pellet-design constraints, with tabulated equation-of-state and radiation transport invoked in the 2-D modeling. We show that radial density tailoring, together with the related, but different, stabilizing hydrodynamic effect of decreasing the initial density of the outer layers of the target, considerably reduces the seed for the RT instability. Compared to the idealized cases studied earlier, the emphasis of density tailoring has to be shifted towards mitigating perturbation growth at very early time, in the outermost layers of the target.
Work partly supported by US Department of Energy.

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ORAL SESSION 4

LASER PLASMA INTERACTIONS

David Meyerhofer, Chair

Tuesday, June 15th, 1999

Wrau

29th Annual Anomalous Absorption Conference
Pacific Grove, CA
June 13-18, 1999

Thomson Scattering on Ion Waves driven by SBS in large-scale length plasmas

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We have performed ultraviolet (4ω) Thomson scattering in a series of experiments at the Nova laser facility to measure ion acoustic waves in mm-size gasbag plasmas (gas fill: CO_2 with $n_e = 6 \times 10^{20}$ cm^{-3} or $n_e = 0.067n_{cr}$ for 3ω laser light). The ion waves are excited to large amplitudes by stimulated Brillouin scattering (SBS) from one Nova interaction beam (3ω) that is smoothed with phase plates and that operates for a range of intensities including the National Ignition Facility (NIF) laser intensity of 2×10^{15} W cm^{-2}. The scattering volume has been chosen to be at a distance of 0.8 mm from the center of the gasbag that has a total radius of ~1.3 mm. The electron temperature and flow velocity gradients at this location have been measured with 90° Thomson scattering on thermal fluctuations and found to reach peak values of T_e = 3 keV and L_V = 0.6 mm, respectively. For the observation of stimulated ion waves, the scattering angle was adjusted to 96° using a periscope in the Nova chamber to allow k-vector matching of the Thomson scattering and the stimulated ion wave k-vectors. Since we measure the scattering spectra temporally resolved with a 1m spectrometer and a streak camera, we can infer the amplitude of the ion acoustic wave compared to the amplitude of the thermal wave on each shot. We find a strong dependency of the ion wave amplitude on the intensity of the 3ω interaction beam. We will discuss the spectral characteristics of the ion acoustic waves, possible effects of large-scale fluctuations, and possible saturation of the ion wave amplitude.

Prefer oral session

The Spatial Location of Stimulated Electrostatic Waves in a Long, Homogeneous, Laser-produced Plasma

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M. R. Lopez
University of Michigan

Abstract

Imaging Thomson scattering is employed to determine the location of both ion acoustic and electron plasma waves responsible for Brillouin and Raman scattering in a 1-mm homogeneous plasma. The waves are produced by a 527-nm interaction beam in the expanding 500-eV plasma near the n/n_{crit} ~5% density contour. The direction of flow in the plasma is perpendicular to the interaction beam. Ion acoustic activity increases in the backscatter direction and saturates in the upstream part of the plasma. However, electron plasma waves may be either upstream or downstream in the plasma and thus often reside in a different region of the plasma than the ion acoustic oscillations. The temporal dependence of wave activity is determined with streak camera records of both the Thomson signal and the backscattered light. For both types of waves, backscatter is not peaked in the direction of the interaction beam lens but is deflected in the direction opposite the flow as much as 10^o.

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Analysis and Simulation of Sound Waves Governed by the Korteweg–de Vries Equation

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Abstract

The filamentation and SBS of laser beams have been observed in numerous ICF experiments. We are interested in how sound-wave nonlinearities modify the evolution of these instabilities. Weakly-nonlinear sound waves are governed by the Korteweg–de Vries (KdV) equation. We have written two codes to solve the KdV equation numerically. The first code is based on the split-step Fourier method, which requires periodic boundary conditions. The second code is based on standard finite-difference schemes, which allow arbitrary boundary conditions. We use analytic solutions of the KdV equation, which exhibit linear dispersion, nonlinear steepening, and soliton propagation, to check both codes. These short codes facilitate the study of weakly-nonlinear sound waves and the testing of longer codes that solve the ion-fluid and Poisson equations (Kozlov and McKinstrie, presented at this conference).

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Prefer Oral Session

29th Annual Anomalous Absorption Conference
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Experimental Study of the Affect of Speckle Size on Backscatter in a Phase Plate Smoothed Beam

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Recent experiments with random phase plate (RPP) and kineform phase plate (KPP) smoothed beams suggest differences between the stimulated scattering (both SBS and SRS) produced with the two types of phase plates, that are not due to the difference in the averaged intensity profile. This has prompted consideration of the effect of the detailed statistical properties of phase plate smoothed beams with the goal of optimizing phase plate design. We have studied the affect of the auto-correlation length of the statistical part of the intensity distribution (speckle size) on the backscatter in a series of experiments with defocused RPP smoothed beams. Numerical simulations of both the RPP and KPP intensity distributions show that away from best focus the speckle size is enhanced compared to what is found at best focus. This has allowed experiments in which the speckle size is varied by defocusing the a RPP smoothed beam while the average intensity is held constant by adjusting the incident power. The targets are gas bags filled with 1 atm. fill of C_5H_{12}, C_3H_8, or CO_2. The targets are pre-heated with 20 kJ of 351 nm light in a 1 ns square pulse which creates a plateau of plasma density and temperature approximately 2 mm in diameter. The focus and power of the interaction beam is adjusted to make the beam diverge throughout the plateau region and to maintain the average intensity at 2×10^{15} W/cm^2 near the edge of the underdense plasma (r = 0.9 mm). By adjusting the focus the speckle size at the plasma edge is varied by 2.5 to 1, with the minimum speckle size produced at best focus. Results indicate that SRS in $C_3H_8$8 increases with speckle size while SBS in CO_2 decreases with speckle size,. and scattering in C_5H_{12} is insensitive to speckle size. The importance of these results for phase plate design will also be discussed.

Prefer oral session

Instabilities of a Single Laser Filament in a Plasma

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Abstract

Steady state laser filaments are well known solutions to the nonlinear Schrödinger equation (with saturated nonlinearity) describing the stationary nonlinear evolution of a laser beam focused within a homogeneous isothermal plasma, whenever the laser beam exceeds the critical power for self-focusing. These steady state solutions have been found[1] to be unstable against the modulational instability due to their coupling with the ion sound waves. It is shown analytically in the present paper that near-forward stimulated Brillouin scattering (FSBS) can develop from the electromagnetic normal modes of the wave-guide formed by the density depletion due to the filament. This radially localized FSBS gives rise to an instability more violent than the modulational one, and manifesting itself in a red-shift in the transmitted light.

Numerical simulations carried out in 2D and 3D show that this instability leads to the disruption of the light filament and to a complicated dynamical behavior in which light refocusing alternates with channel destruction.

[1] V. E. Zakharov and A. M. Rubenchik, Zh. Eksp. Teor. Fiz. **65**, 997 (1973)[Sov. Phys. JETP, **38**, 494 (1974)]; E. Valeo, Phys. Fluids **17**, 1391 (1974); V. Eliseev, D. Pesme, W. Rozmus, V. T. Tikhonchuk, and C. E. Capjack, Physica Scripta, **T75**, 112, (1998).

Twenty-Ninth Annual Anomalous Absorption Conference
Pacific Grove, CA
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Flow-induced beam steering in the Trident single hot spot experiments*

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Nonlinear beam steering in a plasma with transverse flow is studied in experiments using the Trident laser. A diffraction-limited 527 nm beam is used to interact with a well-characterized, long-scalelength plasma. The laser is focused to a 3.8 μm spot using a high-quality f/6.9 lens, and the laser energy is varied to scan the intensity in the range of 10^{14} - 10^{16} W/cm^2 in a 200 ps pulse. Backscattered SRS and SBS, and the transmitted beam angular distribution were measured for the diffraction-limited beam in these plasmas.

Experiments were performed in CH plasmas for densities of $n_e/n_{cr} \sim 0.05$ with sub-sonic, trans-sonic, and super-sonic transverse flows. For Mach numbers ≥ 1, the beam was deflected up to angles of 8° beyond refraction only. Significant beam spraying with no centroid deflection was observed for sub-sonic flows. Continuous angularly resolved spectra of the transmitted beam were also obtained, and show significant spectral broadening in experiments with sub-sonic transverse flow. Experimental results and recent numerical simulations of beam steering in these flowing plasmas will be presented.

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Prefer Oral Session

Nonlinear Hydrodynamic Simulations of SBS in Laser Hot Spots

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Abstract

We present two dimensional simulations of SBS in a plasma with multiple laser hot spots. The nonlinear fluid response of the plasma is resolved using a conservative, high order Godunov type method[1], and includes a paraxial description of the incident, and backscattered light using a time splitting method. The incident light is taken to correspond to either a spatially and/or temporally incoherent laser beam. Although kinetic effects are ignored[2], many potentially important nonlinearities are included in the model.

We use this code to consider SBS in a plasma characterized by an inhomogeneous flow. We investigate the effect of long scale flow fluctuations[3] driven by momentum transfer[4] in the case of multiple laser hot spots.

1. R. L. LeVeque, *Wave Propagation Algorithms for Multidimensional Hyperbolic Systems*, J. Comput. Phys. **131**, 327 (1997).

2. See Poster: *Two-dimensional Particle Simulations of SBS in Multiple Laser Hot Spots*, C. Riconda, S. Hüller, J. Myatt, D. Pesme, and Ph. Mounaix.

3. A. A. Maximov, W. Rozmus, V. T. Tikhonchuk, D. F. Dubois, H. A. Rose, and A. M. Rubenchik, Phys. Plasmas **3**, 1689 (1996).

4. H. A. Rose, Phys. Plasmas **4**, 437 (1997).

Random doppler shift

Forward SBS, Filamentation, and SSD

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Abstract

Filamentation can be regarded as the special case of forward stimulated Brillouin scattering for which the real frequency of the plasma density perturbation vanishes. Both filamentation and forward SBS arise from the same physical processes and are described by the same dispersion relation. For mathematical convenience, approximations are often made that allow the two instabilities to be treated separately. This is justifiable for laser beams with spatial structure but no bandwidth, since then the seeds for the two instabilities are different: SBS arises from time-dependent thermal fluctuations in the plasma and filamentation from the temporally invariant intensity structure of the beam. When bandwidth is added, as in the case of SSD, the spatial structure of the beam acquires a time dependence as well, so that the intensity variations in the beam now drive finite-frequency forward SBS modes as well as zero-frequency filamentation modes. Since forward SBS can have significantly higher growth rates than filamentation and can lead to similar increases in intensity, this effect is of interest in assessing the efficacy of SSD in reducing intensity-enhancing instabilities. Using contour plots of the growth rates and frequencies for SBS-filamentation modes obtained from the complete dispersion relation encompassing both instabilities, the relative significance of these modes and their response to changes in bandwidth can be estimated.

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Prefer Oral Session

INVITED TALK 2

Nonlinear propagation of Laser Beams in a Plasma

by

Wojtek Rozmus
University of Alberta

Tuesday, June 15th, 1999
Hector Baldis, Chair

Nonlinear Propagation of Laser Beams in a Plasma*

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The ion wave response to intense laser beams in ICF relevant plasmas is discussed in terms of recent numerical, theoretical and experimental results. We review results of numerical simulations in two and three spatial dimensions carried out by using a code solving non-paraxial electromagnetic and ion-acoustic wave equations.

Self-induced plasma smoothing of spatially incoherent beams is displayed by angular and spectral broadening of the transmitted light. This process is quantified by calculating correlation functions and is explained in terms of dynamical self-focusing and forward stimulated Brillouin scattering (SBS). A change in the beam intensity distribution, mainly the decrease of a hot spot size, which is related to self-smoothing is responsible for the reduction of the backward SBS reflectivity.

A fundamental process associated with dynamical self-focusing is an instability of laser filaments which exceed the critical power due to their coupling with ion acoustic waves. The most pronounced manifestation of this process is a forward SBS of the electromagnetic normal modes trapped within the density depletions formed by laser filaments. Summary of numerical results will demonstrate large, intensity dependent red shift of the transmitted light due to radially localized forward SBS.

Processes contributing to the self-smoothing of spatially incoherent laser beams are well illustrated in simulation and experimental results obtained from plasmas irradiated by two crossed laser beams. This particular geometry of a great importance to ICF also leads to specific processes related to the energy exchange between the beams and density grating produced by the interference of crossing beams.

* *This review includes collaborative work with:* H. A. Baldis, C. E. Capjack, V. Eliseev, C. Labaune, A. Maximov, I. Ourdev, D. Pesme, C. H. Still, V. T. Tikhonchuk and P. Young.

MIXED POSTER SESSION 2

Tuesday, June 15th, 1999

Twenty–Ninth Annual Anomalous Absorption Conference
Asilomar Conference Center, Pacific Grove, California
13-18 June, 1999

Stimulated Brillouin Scattering in the Presence of a Filamenting Pump Non-Local Heat Transport and a Turbulent Plasma

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We calculate the propagation and amplification of the scattered light wave in a three wave Brillouin instability (SBS). We take into account the fine scale spatial distribution of the pump which is filamented, diffraction of the scattered light beam, velocity fluctuations or turbulence in the plasma, and non-local heat transport which introduces a spatially varying sound speed to the ion acoustic waves (IAW). We compare and contrast the effectiveness of all these mechanisms to suppress SBS especially in the strong IAW damping limit. Axial redistribution of laser energy due to filamentation is seen to severely diminish the correlation length of intense hot spots in filamented laser beams which in turn fragments the available gain length for SBS. The concept of I*L statistics is extended by including the diffraction of the scattered wave so that the new results go beyond straight line rays, as we had treated previously (See also the poster by Fleischman et al. on I*L statistics).

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PREFER POSTER SESSION

Twenty-Ninth Annual Anomalous Absorption Conference
Asilomar Conference Center, Pacific Grove, Ca
13-18 June 1999

Imprint modeling in direct-drive laser-fusion pellets*

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Two major sources for nonuniformity in direct-drive laser-fusion are the mass imperfections in the physical media of laser targets, and the nonuniformity of the laser drive. The former source is steadily becoming smaller as advances in manufacturing techniques continue to improve; current state-of-the-art targets have measurable imperfections on a scale as small as a few hundred Angstroms. Imprinting from laser drive nonuniformity is more difficult to measure directly. It is a dynamic process that depends not only upon laser parameters such as wavelength and bandwidth, but also upon the characteristics of the target design that determine mass ablation rates, absorption-to-ablation standoff distances, etc. Instead of direct measurement, we rely upon indirect experimental observation and numerical simulations to predict the severity of laser imprinting.

One approximation common in numerical simulations of imprinting of direct-drive targets is to represent the propagation and deposition of laser light energy with a ray-tracing model. Ray tracing neglects interference effects that can significantly change the structure and deposition of the laser electric field, and thus affect its imprint on the ablation surface. Improving upon this approximation requires a model that describes both the interference of the laser field with itself and the propagation of the light near and at its turning points. Paraxial light propagation modeling is insufficient for this latter requirement. We have integrated a split-step spectral EM wave solver[1] with our target design hydrocode (FAST) [2]. Simulations of imprint with this improved model are presented and compared to corresponding predictions from ray-trace simulations.

[1]"*SOFTSTEP: A scalar parabolic PDE solver in any number of dimensions: A User's Manual*" POLYMATH REPORTS Vol **I**, number 1, 1999.

[2] "*Computational modeling of direct-drive fusion pellets and KrF-driven foil experiments*", J. H. Gardner, A. J. Schmitt, J. P. Dahlburg, C. J. Pawley, S. E. Bodner, S. P. Obenschain, V. Serlin, Y. Aglitskiy, Phys. Plasmas **5**, 1935 (1998).

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Poster Session Requested

Twenty–Ninth Annual Anomalous Absorption Conference
Asilomar Conference Center, Pacific Grove, California
13-18 June, 1999

I*L Statistics of Filamenting Laser Beams: Statistical Properties of Laser Beams Propagating in Inhomogeneous Plasmas Near or Far From Their Turning Points

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We calculate the statistical properties of Gaussian and speckled incident laser beams propagating in inhomogeneous plasmas. We also characterize the intensity and phase distributions resulting from the overlap of multiple laser beams. We do this in the linear propagation regime as well as the filamenting regime with instantaneous ion response and saturable nonlinearity.

Our aim is to flesh out the details of I*L statistics of filamenting beams including the effects of the inhomogeneity of the plasma which changes the wavevectors of the overlapping beamlets as they propagate. Analytic and semi-analytic Green's function results are compared to full scale numerical simulations using SOFTSTEP spectral codes.

These results are used in companion papers presented at this conference to calculate the properties of stimulated Brillouin scattering (SBS) and $2\omega_{pe}$ in plasmas with overlapping structured laser beams.

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PREFER POSTER SESSION

Two-dimensional simulations of Raman and two-plasmon scattering in a modulated-density plasma

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In the domain of inertial confinement fusion, Raman scatter is a major concern in long, hot plasmas typical of the ones that will be generated by megajoule-class lasers. One-dimensional gain models for very simple plasmas have been unable to predict the typical length for Raman growth, by orders of magnitude. The intricacy of wave couplings, in both their linear and nonlinear regimes, requires full simulation of all couplings, which is now accessible on large computers.

Two-dimensional particle simulations have been performed in order to analyze the behavior of both Raman and two-plasmon decay in one laser speckle. The plasma density profile is a plateau on which axial or transverse short-wavelength density modulations (as would be driven by Brillouin scatter) are superimposed. The focal number and laser irradiance have been varied from 1 to 4 and 2 10^{15} to 10^{16} W/cm^2, respectively. Both microscopic and macroscopic diagnostics are provided: the wave-vector spectra of the longitudinal and transverse waves, their growth rates, the frequency spectrum, the integrated energy, and the transverse distribution of backscattered light.

Numerical Two-Dimensional Studies of Near-Forward Stimulated Brillouin Scattering of a Laser Beam in Plasmas

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Abstract

In previous papers [1, 2] we studied analytically the one-dimensional spatiotemporal evolution of near-forward stimulated Brillouin scattering (SBS) in different regimes. To expand this analysis we have developed a code that solves the paraxial light-wave equation in conjunction with the ion-acoustic wave equation in two-dimensional Cartesian geometry. The code is based on arbitrary nonperiodic boundary conditions in the propagation direction of the light wave and periodic boundary conditions in the transverse direction. This model allows the investigation of three- and four-wave coupling in the context of near-forward SBS, and its role in the power transfer between two crossed laser beams, along with filamentation and focusing. We validated our code by comparing the numerical results to our previous analytical results.

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[1] C. J. McKinstrie, J. S. Li, and A. V. Kanaev, Phys. Plasmas **4**, 4227 (1997).
[2] A. V. Kanaev and C. J. McKinstrie, Phys. Plasmas **5**, 4511 (1998).

Prefer Poster Session

Photon Kinetics for Laser-Plasma Interactions*

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Abstract

In the early days of Quantum Mechanics, Wigner [1] showed that a quantum field could be described by a quasi-classical phase space distribution - the Wigner function. Later, Moyal [2] derived the transport equation for the Wigner function, which, to second order in $\hbar$, is formally equivalent to the Vlasov equation. These concepts have been also applied by Tappert and co-workers [3] to the propagation of classical electromagnetic fields in random media in the one dimensional limit.

We describe here the classical photon kinetics of intense broad spectrum laser fields in plasmas, and the associated forward scattering photon driven instabilities. The electromagnetic field is described by the number of photons distribution function N. For underdense plasmas, the evolution of N is governed by a kinetic equation equivalent to the Vlasov equation. The growth rates for Stimulated Forward Raman and Brillouin Scattering are rederived. Employing the quasi-particle picture provided by the photon kinetic description, we have extended WAKE [4] in order to include the self-consistent propagation of photons. Issues associated with the numerical implementation of a Quasi-Particle in Cell code are discussed (photon pusher, photon loading). Comparison between the analytic and the numerical results will be provided. Discussion of possible extensions of the photon kinetic equation to include quantum processes involving the photons will also be presented.

[1] E.Wigner, Phys.Rev. **40**, 749 (1932).
[2] J.E.Moyal, Proc.Cambridge Phil. Soc. **45**, 99 (1949).
[3] I.M.Besieris and F.D.Tappert, J.Math.Phys. **17**, 734 (1976), and references therein.
[4] P.Mora and T.M.Antonsen Jr., Phys.Plasmas **4**, 217 (1997).

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Suppression of Raman gain in an inhomogeneous plasma by finite amplitude ion acoustic waves.

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Conventionally stimulated Raman scattering, SRS, and stimulated Brillouin scattering, SBS, have been investigated as independent instabilities even though it has been acknowledged for some time that they may not evolve independently but can interact with one another in a variety of ways. For example the parametric decay of Langmuir daughter waves from SRS can lead to the generation of a spectrum of Langmuir waves and ion acoustic waves which in turn may result in saturation of the Raman instability [1,2]. Recent experiments [3] have provided compelling evidence of a link between SRS and SBS, reviving interest in coupling between the two. In particular these experiments provide direct evidence of both spatial and temporal interaction between ion sound waves and Langmuir waves under conditions that ensured both instabilities were below saturation levels.

We have examined a complex five-wave Raman scattering event in an *inhomogeneous* plasma in which a finite level of ion acoustic waves is present. The daughter plasma wave from a normal three-wave Raman event in turn decays parametrically into a second plasma wave and an ion acoustic wave. These decays are assumed to take place locally so that matching conditions for SRS and the subsequent parametric decay occur together. We have shown that the outcome is that SRS is suppressed at very modest levels of ion acoustic noise under conditions similar to those investigated in [3].

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[1] G. Bonnaud, D. Pesme and R. Pellat, Phys. Fluids, **B2**, 1618 (1990)
[2] T. Kolber, W. Rozmus and V.T. Tikhonchuk, Phys. Fluids **B5**, 138 (1993)
[3] C. Labaune et al., Phys. Plasmas, **4**, 423 (1997)

Abstract submitted to the 29th Annual Anomalous Absorption Conference
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Spectral Evidence for Collisionless Absorption in Sub-Picosecond Laser-Solid Interactions†

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Second harmonic emission produced by the interaction of an ultra short laser pulse with solid aluminum has been spectrally analyzed. The experiments were performed on the LLNL USP laser which 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 dependence of the reflectivity on the angle of incidence with respect to the target normal indicates that the laser is interacting with a density gradient $L/\lambda \sim 0.3$. For an angle of incidence near 20° and P polarization, the specular second harmonic is blue shifted when the laser intensity exceeds 1×10^{17} W/cm^2. The blue shift is consistent with analytic modelling of collisionless absorption due to the nonlinear electron oscillation in the plasma sheath driven by the component of the laser electric field normal to the target. This interpretation is supported by the observation that no blueshift is observed when the incident laser is S polarized. Preliminary results from PIC simulations show similar spectral shifts at higher laser intensities. The difference between simulation and experiment may be due to filamentation of the laser or to deformation of the critical surface, for which there is evidence in the reflected light pattern.

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Propagation of intense and short laser pulses through underdense plasmas : effect of the laser intensity and of the plasma density

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The propagation of an intense laser pulse (>10^{18} W/cm^2) in a long underdense preformed plasma is a key issue for the Fast Ignitor concept. In this respect, the role of the electronic instabilities arising at relativistic intensities must be clarified both experimentally and theoretically.

We will present recent results obtained during an experiment performed on the P102 laser facility at CEA. Transmission and reflection of a 1 μm-500 fs laser pulse shot onto a nanosecond pulse-created CH plasma have been measured, as well as the Raman forward/backward scattered light and the fast electron generation. Moreover, an interferometric diagnostic allowed determination of the plasma density, that is, both the preformed plasma density profile and the density channel.

The first set of shots have been performed at a density of 10^{20} cm^{-3} in the intensity range 10^{17} to 10^{19} W/cm^2. A preliminary analysis shows that the reflection peaks at an intensity of 3×10^{17} W/cm^2 at this density. On the contrary, the transmission versus intensity remains constant at about 20%. The Raman backscatter saturates around 20% while the Raman forwardscatter continuously increases as the laser intensity increases without evidence of saturation.

In a second step, the maximum density of the plasma has been reduced while keeping the laser intensity at $1.5\text{x}10^{18}$ W/cm^2. Again, the Raman forwardscatter continuously increases as the density decreases, and the Raman backscatter level remains high.

The Raman forward scatter is correlated with the emission of fast electrons in the range 0.5-5.5 MeV. The Raman spectra appear substantially wide (> 200 nm) as if evidencing the merging of instabilities predicted in recent analytical works[1]. Yet, these theoretical models do not properly address the effects of a strong heating, which is likely to play an active role in the temporal growth or inhibition of the instabilities. To investigate this particular issue, the first steps of a numerical approach of the problem will also be exposed.

[1]S. Guérin *et al.*, Phys. Plasmas **2**, 2693 (1995), B. Quesnel *et al.*, Phys. Plasmas **4**, 3358 (1997).

Prefer poster session.

29th Annual Anomalous Absorption Conference

Channeling and Filamentation of Intense Sub-Picosecond Laser Pulses[1]

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The massively parallel nonlinear fluid hydrodynamics laser-plasma interaction code pF3D, which includes relativistic modifications to the index of refraction and ponderomotive drive, has been upgraded to include the effects of charge separation, as is appropriate for sub-picosecond laser pulse analyses. The 0.5 ps FWHM laser pulse of peak intensity 2×10^{19} W/cm^2 (typical of the Petawatt laser at LLNL[2]) is propagated through plasma profiles with scalelengths ~ 2 mm. Both unaberrated and phase aberrated laser beams have been simulated. Results with and without charge separation effects will be presented.

[1] This work was performed under the auspices of the U. S. Department of Energy by the Lawrence Livermore National Laboratory under Contract No. W--7405--Eng--48.
[2] "Petawatt laser pulses", M. D. Perry, D. Pennington, et al, Optics Letters **24**, 160 (1999).

Particle-in-Cell Simulation of Ponderomotive Particle Acceleration in a Plasma

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Abstract

Previous analytical calculations suggest that a preaccelerated test particle can be ponderomotively accelerated to energies in excess of 100 MeV by an intense electromagnetic pulse propagating in an underdense plasma [1]. To check these predictions we have developed a relativistic, two-dimensional particle-in-cell code. Test simulations that validate the code will be described in detail. Preliminary simulations of the interaction of a preaccelerated electron bunch with an electromagnetic pulse in a plasma will be presented.

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[1] C. J. McKinstrie and E. A. Startsev, Phys. Rev. E **54**, R1070 (1996); **56**, 2130 (1997).

Prefer Poster Session

29th Anomalous Absorption Conference Pacific Grove, CA

Ultra-Intense Laser Plasma Effects: GigaGauss magnetic fields, relativistic electron beams, and ultra-high target potentials*

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Self-generated magnetic fields up to 10^9 Gauss have been predicted in plasmas irradiated with ultra-intense laser light. In addition, intermittent relativistic electron beams have been observed.[1] Various aspects of these two novel phenomena, including a possible connection, are discussed. Target charging to a potential of 10-100 MeV is also considered.

1) T. Cowan, private communication (1999)

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Poster presentation requested.

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29th Annual Anomalous Absorption Conference
13-18 June 1999

Experimental Studies Of Three-halves Harmonics From Al Target Irradiated By Ultra-intense Laser Light.

Michiaki Mori

M. Mori, Y. Kitagawa, R. Kodama, K. A. Tanaka, H. Habara, T. Koase, S. Nakata, K. Suzuki, K. Sawai, Y. Sentoku, K.mima, T.yamanaka And S. Nakai

ILE, Osaka Univ.

Abstract

The 45TW/0.45ps GEKKO MII Ti:Sapphire-Nd:glass hybrid CPA laser system has used for study of ultra-intense light and plasma interactions. We have been studying fast ignition using this system. We measured three-halves harmonics from Al target to study the ultra intense laser transport in the region from nc/4 to over nc densities. The ultra intense light (maximum intensity: 6e18 W/cm2, wavelength:1053nm) was illuminated on 20 micron thick Al plane. The spectrum and intensity of three-halves harmonic was measured. As increasing laser intensity, the spectrum was red shifted, broadened and modulated The polarization effect on the three-halves scatters are also investigated as well as the angular dependence. We have compared them with second harmonics scattering from nc.

29th Annual Anomalous Absorption Conference
13-18 June 1999

High Brightness Electron Beams Produced By Laser Ionization Of Gases

Christopher Moore

C. I. Moore, A. Ting, S. Mcnaught, T. Jones, B. Hafizi, And P. Sprangle

Naval Research Laboratory

Abstract

Energetic electron beams (E~1 MeV) have been produced by the laser ionization and ponderomotive acceleration (LIPA) of electrons from high charge states of gases. These highly directional beams are well suited for injection in electron accelerators. Electrons are accelerated by a combination of the ponderomotive potential and canonical momentum conservation. Experimental measurements are compared with simulation results to study various issues associated with the electrons' energy and angular distributions. Results of these studies will be presented.

Laser Pulse Propagation through a Thin Lens

C. Ren, B. J. Duda, W. B. Mori
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T. M. Antonsen, Jr.
University of Maryland, College Park
T. Katsouleas
University of Southern California
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Centre de Physique Theorique, Ecole Polytechnique

In previous theoretical and experimental studies of relativistic self-focusing, a laser pulse is assumed to propagate through long regions of plasma. Under these conditions, the self-focusing distance is short compared to the plasma length and the laser is susceptible to other self-modulation processes such as Raman forward scattering. In the present study, we consider the situation where a thin region of plasma is used such that the laser is primarily focused outside the plasma region. This thin plasma lens concept is studied analytically and via the simulation code WAKE. It is found that the separation between the plasma boundary and the final focus can be on the order of several centimeters and the laser's intensity can be enhanced by a factor of 2.5. This may provide an opportunity to conclusively verify relativistic self-focusing effects as opposed to optical guiding effects in near term experiments. The major limitation of a thin plasma lens design is the occurrence of Raman forward scattering. As part of this study, we have used the variational principle approach study relativistic self-focusing including finite pulse length effects. Analytical expressions for the nonlinear phase and group velocity are obtained which reduce to the vacuum results of Esarey *et al.* [1] and the long-pulse results of Decker and Mori [2].

Work supported by DOE, NSF, and LLNL.

[1] E. Esarey *et al.,* Journal of Optical Society of America B, **12**, 1695 (1995).
[2] C. D. Decker and W. B. Mori, Phys. Rev. Lett. **72**, 490 (1994).

29th Annual Absorption Conference
June 13 – 18, 1999

John

Visited wineries with John + Glenn

Ablative Rayleigh-Taylor Instability in Indirectly Driven thin Aluminum Foils

J Edwards, B Lasinski, K S Budil, A S Wan, B A Remington, L Suter, P E Stry, and S V Weber, LLNL

The stabilization of the Rayleigh-Taylor instability due to finite density gradients and material ablation has become a well known and studied phenomenon in recent years, not least because of it's particular importance to the achievement of laboratory fusion. The most pronounced stabilization occurs at short wavelengths where a rapid roll-over to zero is expected in the growth rate dispersion curve. The position and shape of this roll-over are difficult to measure because typical spatial scales are comparable to instrument resolutions, and the small growth rate demands adequate growth times to make the growth of perturbations observable. The precise effect of the stabilization and roll-over is situation dependent, and until recently, predicted growth rates have been derived either from direct numerical simulation or estimated from a simple formula[1] whose coefficients have been estimated by comparison with direct simulation and experiments. Here we present the results of experiments in which thin ~ 25 μm aluminum foils have been accelerated by X-rays from a gold ~120 eV Nova hohlraum at roughly constant acceleration for a period of up to approximately 5 ns. The growth of 10 μm to 70 μm wavelength perturbations imposed at the ablation front was measured with face-on X-radiography. Strong stabilization was observed at the shortest wavelengths; growth at 10 μm and 12 μm was unobservable out to 5ns; growth at 16 μm was much reduced relative to that at 20 μm, above which strong growth was observed even at early times. The data are used to test the suitability in this regime of recent self-consistent linear theory[2], and both theory and experiment are compared with 2D numerical simulation.

1. H Takabe, K mima, L. Montierth, and R. L. Morse, Phys. Fluids 28, 3676 (1985).
2. R. Betti, V. N. Goncharov, R. L. McCrory, and C. P. Verdon, Phys. Plasmas **5**, 1446 (1998).

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LA-UR-99-1662
Poster-Preferred

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

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We have extended earlier computational and experimental studies[1] of Rayleigh-Taylor instability to Beryllium-buffered thin planar copper foils, radiatively driven in OMEGA hohlraums. The foils were typically 11.5 μm thick, with 45 μm wavelength drive-side surface perturbations of 0.5 μm amplitude, with and without a 5 μm Be-buffer layer on the drive side. Both flat and conformal buffer layers were studied. The hohlraums were heated by a "P26" laser pulse. This yielded a peak radiation temperature of 160 eV after about 1.5 ns, which began dropping again toward 90 degrees after 2.3 ns. The foils were accelerated by this radiative drive. The developing bubble-and-spike pattern in the foil was analyzed with a 6.7 keV backlighter, looking normal to the foil and its initial corrugations. Over 3 ns the conformal buffered simulations indicate a shocking of the foil and a displacement of its rear to ~100 μm, with growth of the 1st harmonic of the initial perturbation to amplitudes exceeding 6 μm, and growth of the 2nd harmonic to 2 μm after 4 ns. The 1st harmonic data is in good agreement with experiment.

This evolution has been modeled both with 2D LASNEX, and with the AMR Eulerian RAGE code. LASNEX provided early-time 2D results, and speedy 1D-parameter studies of the buffering possibilities. The Eulerian calculations permitted evaluations far into the non-linear, bubble and spike regime for the RT instability. We discuss subtleties arising from modeling of the initially smooth cosine perturbations with a stair-stepped AMR mesh, and the relative influence of radiative diffusion and electron thermal conduction on the "fire-polishing" away of small-scale disturbances. We compare foil accelerations and stability, with and without the various buffer layer configurations.

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1. R. J. Mason, D. E. Hollowell, G. T. Schappert, and S. E. Caldwell, , R. P. Weaver, Bull. Am. Phys. Soc. **8**, 1895 (1998).

Rayleigh-Taylor Instability Initiated by Acoustic Waves*

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Key words: Rayleigh-Taylor instability, acoustic waves, nonlinear wave interaction, numerical simulation, feedout

An acoustic wave traveling from a stable accelerated fluid into an unstable region triggers Rayleigh-Taylor growth in the unstable region. This is a nonlinear wave interaction, requiring a treatment via 2nd-order theory. We expect a situation something like this to arise in ICF capsules when perturbations travel as acoustic waves from the inside of the capsule outward to the ablation surface, a process called feedout. As a step towards a fundamental understanding of this process, we present numerical simulations of acoustic waves traveling up the density gradient (i.e., downward) in a stable hydrostatic atmosphere and entering an unstable layer of reversed density gradient, where they stimulate Rayleigh-Taylor instability. We also give results from a 2nd-order analysis of the wave interaction.

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Prefer poster presentation

Radiative hydrodynamics experiments for astrophysics

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We report on two experiments relevant to radiative hydrodynamics for astrophysics. In astrophysical plasmas, radiative effects can significantly modify the hydrodynamic evolution. We focused on two radiative-hydrodynamics phenomena of astrophysical interest – radiative blast waves and radiative jets.

The propagation of blast waves is of fundamental importance in determining the structure of the interstellar medium. To develop a laboratory testbed for astrophysically relevant shock physics, we performed an experiment using the high intensity, short pulse Falcon laser at Lawrence Livermore National Laboratory and a gas jet target [1]. Gas targets of N_2, Ar, and Xe at ion densities of ~10^{18} cm^{-3} were irradiated using F/15 optics with 30 fs Ti: sapphire laser. Such gas jet targets form atomic clusters which strongly absorb laser light, creating a high-temperature initial plasma. We measured the electron density of the plasma by Michelson interferometry, and observe a 1-D cylindrical hot plasma of initial dimensions 50-μm diameter by 2-mm length of temperature ~70 eV. This launched a radially propagating strong blast wave. Experimental results were compared with the self-similar Sedov-Taylor blast-wave theory and with the 1-D hydrodynamics code HYADES and LASNEX. The trajectories of the blast wave front show good agreement with the 1-D simulation results. However, the experimental trajectories were slightly slower than the classical Sedov-Taylor theory, due to the loss of energy from the shocked plasma due to radiation. We also observed the radiative precursor ahead of the shock front for from the interferometry. Experimental results indicate that these radiation effects are significant for high-Z gas, but insignificant for low-Z gas.

Astrophysical jets, such as Herbig-Haro (HH) jets are one of most exiting events in the universe. Numerical studies indicate that in some cases the formation of a well-collimated astrophysical jet is strongly connected with radiative cooling. Our recent experimental study shows we are able to create a radiatively collapsing jet in laboratory using high-power laser [2]. Experiments were performed at the GEKKO-XII laser facility at Osaka University. Conical targets of Au, Fe, Al, and CH were irradiated by a short (FWHM: 100 ps) intense (> 5 x 10^{14} W/cm^2) pulse of λ_L=0.528 μm laser light, using 6 beams at 100 J/beam. We measured x-ray emission from the jets ejected from the axis of the cone by x-ray framing camera and x-ray streak camera. We observed well-collimated x-ray emission and the diameter of the emission increases as atomic number of the jet plasma decreases. This observation suggests that radiative cooling is very strong, leading to a radiative collapse on axis for high-Z jets, whereas low-Z jets are more nearly adiabatic, and do not collapse. This observation is consistent with the results of 2-D LASNEX simulations.

We will present results from both experiments, radiative shocks and radiative jets, and discuss their astrophysical implications. *Work performed under the auspices of the U.S. DOE by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48, and supported in part by LLNL LDRD grant No. 98-ERD-022, and JSPS Fellowship No. 0733.

[1] K. Shigemori *et al.*, to be submitted to Astrophys. J Lett (1999).
[2] D. R. Farley *et al.*, submitted to Phys. Rev. Lett. (March, 1999); UCRL-JC-133046.

Shock compressed solids on the Nova laser

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Material strength can be important in the plastic flow of solid state materials at high pressure, affecting the growth of perturbations due to the Rayleigh-Taylor instability.[1,2] In order to study the material properties of metal foils at pressures up to several Mbar, we compress the foils with staged shocks using a temporally shaped x-ray drive generated in a Nova hohlraum target, and observe the growth of pre-imposed modulations by x-ray radiography. Thin Al foils are mounted in contact with a bromine doped polystyrene ablator. These foils are then compressed quasi-adiabatically to a peak pressure of 1.4 Mbar. A detailed x-ray drive characterization has been done, including measurements of shock speed, preheat, and foil trajectory. The x-ray drive was calculated by a view-factor analysis, and also by a full hohlraum simulation for the shielded hohlraum used in this experiment. With the resulting drive model, the Al foil is calculated to remain solid throughout the experiment. The material strength properties of Al are predicted to reduce the instability growth of pre-imposed modulations at the embedded ablator-metal interface by factors of 2 or more compared to classical (fluid). We present details of the x-ray drive characterization, modeling, and results of the instability growth measurements in Al foils with 10-50 μm wavelength perturbations.

[1] J. F. Barnes et al, J. Appl. Phys. 45, 727 (1974).
[2] A. I. Lebedev et al, Proc. 4th IWPCTM, 29 March-1 April, 1993.

Work performed under the auspices of the U.S. D.O.E. by Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.

29th Annual Anomalous Absorption Conference
13-18 June, 1999

Ablative Rayleigh-Taylor Instability in Spherically Confergent Geometry

S. G. Glendinning, O. L. Landen, B. A. Remington, R. J. Wallace, D. Galmiche, C. Cherfils, P. A. Holstein, A. Richard
Lawrence Livermore National Laboratory

We have performed ablation front Rayleigh-Taylor experiments in spherically convergent geometry using the Nova laser. In previous experiments, germanium-doped capsules 450 μm in diameter were indirectly driven in gold hohlraums 1600 diameter X 2400 μm long, converging about a factor of two. Decreasing wavelength was observed to affect the onset of nonlinearity. The goal of the recent experiments was to examine growth at higher convergence than previously. Germanium-doped plastic capsules 750-900 μm in diameter were imploded in hohlraums 2400 μm diameter by 3400-4200 μm long. Legendre mode 24 surface modulations imparted by laser ablation were observed to grow by radiography while the capsule diameter converged by a factor of four. The symmetry of the imploding capsule was also observed from the radiographs.

Ablator Characterization Experiments on Nova with Brominated Plastic and Copper doped Beryllium [1]

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S.V.Weber, G.W. Collins, (Lawrence Livermore National Laboratory, CA).

The ablation of the outer layer of an ICF capsule, which is mainly responsible of the target`s hydrodynamic, is a fundamental problem for ignition. Joined experiments were performed in the frame of a CEA/US DOE collaboration to investigate ablation physics using Nova Laser Facility with Brominated plastic and Copper doped Beryllium planar foils. The efficiency of the ablation was characterized by measuring burnthrough timing, shock breakout timing and foil velocity in order to relate the radiative wave velocity and shock wave velocity to the incident drive. We report on comparison of numerical simulation with experimental data for brominated plastic ($CH_{1-x}Br_x$, x=0.054) and Beryllium with various concentrations of doping. With the prcision of the timing measurement corresponds an uncertainty in the opacity of 20% and 2% in the drive temperature.

[1]Work performed in the frame of a Commissariat à l`Energie Atomique / Department of Energy Collaboration.

✓ poster session.

29th Annual Anomalous Absorption Conference
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Electron and Ion Jet Formation in Ultra Intense Laser Plasmas

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Long-scale jet-like x-ray emission was observed in the experiments on the interactions of 100 TW laser light with plasmas. The jet formation is investigated by simulations with a two dimensional relativistic particle code. When an S-polarized intense laser is irradiated obliquely on an overdense plasma, collimated MeV electrons are observed from the critical surface in the specular reflection direction.These electrons are found to be accelerated through the coronal plasma by the reflected laser light, which was modulated at the reflection point. The quasisteady magnetic channel occurs simultaneously and collimates the energetic electrons along the specular direction. In the case of P-polarized laser, it is found that an outgoing electron stream is induced at the critical surface due to Brunel mechanism. Megagauss quasistatic magnetic fields are generated and pinch the electron stream. The angle of ejected electron depends on the electron's energy. The emission direction of the jet generated by the P-polarized light is determined by the canonical momentum conservation along the target surface. Hot electron jets penetrating into the overdense plasma are discussed for an interest in the fast ignition scheme.

Also the GeV ion jets generation by the ultra relativistic (nomarlized vector potential $a > \sqrt{m_i/m_e}$) laser pulse is studied for the case of a flat thin foil and a deformed one. The acceleration of ions is extremely enhanced by the deformation, since high absorption of the laser energy and focusing of the transmitted pulse could be happen. Energetic ion jets are collimated with the help of the self-generated quasistatic magnetic fields.

LLNL Nova and Gekko laser experiments of radiative astrophysical jets. **Kent Estabrook,[1] Bruce Remington,[1] Keisuke Shigemori,[2] Dave Farley,[1] Siegfried Glenzer,[1] R.E.Turner,[1] Gail Glendinning,[1] George Zimmerman,[1] J.H.Harte,[1] D.S.Bailey,[1] R.J.Wallace,[1] R.W.Lee,[1] Kevin Fournier,[1] R.Kodama,[2] R.Koase,[2] Y.Ochi,[2] H.Azechi[1], James Stone,[3] and Neal Turner,[3]** [1]*Lawrence Livermore National Laboratory, University of California,* [2]*Institute of Laser Engineering, Osaka University, Suita, Osaka, Japan and Institute for Laser Science and Applications(LLNL),* [3]*U.Maryland, College Park.*

Studying the dynamics of astrophysical jets is important to understand the details revealed by astronomical observations of these sources [1]. In some systems, radiation losses are important to the dynamics. Using LLNL's Nova[2] and Osaka's Gekko lasers, we create CH, Al, Fe and Au plasma jets at velocities of several x 10^7 cm/sec with direct laser illumination on cones. We use Thomson scattering to measure electron temperatures, and we image x ray self-emission and x ray backlighted radiography. For the high-z Au jet, the electron temperature cools by an order of magnitude in 1/2 nsec to form a high aspect ratio cylinder. The collapsed radius increases as the atomic number decreases due to less radiative cooling for low-z plasmas. Comparison with 2-D LASNEX simulations will be shown. In dimensionless terms, this jet is similar to several aspects of radiative astrophysical jets.

[1] J. M. Stone, J. J. Xu, P. E. Hardee, *Astrophysical J.* **483**, 136 (1997); J. M. Blondin, B. A. Fryxell and A. Konigl, *Astrophysical J.* **360**, 370 (1990).

[2] D. R. Farley, K. G. Estabrook, S. G. Glendinning, S. H. Glenzer, B. A. Remington, K. Shigemori, R. J. Wallace, G. B. Zimmerman and J.A.Harte, submitted to *Phys.Rev.Lett.*

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

Abstract submitted to the 29th Anomalous Absorption Conference, Pacific Grove, CA, June 13-18, 1999

poster please on Monday, Tuesday or Wednesday

29th ANNUAL ANOMALOUS ABSORPTION CONFERENCE

Hydrodynamic Instabilities in Supernova Remnant Simulation Experiments

R. Paul Drake, Tim Smith, H.N. Reisig
University of Michigan,

S. Gail Glendinning, Kent Estabrook, Omar Hurricane,
Bruce A. Remington, Russell Wallace
Lawrence Livermore National Laboratory,

James J. Carroll III,
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Eli Michael, Richard McCray,
University of Colorado.

Natural plasma systems are replete with hydrodynamic phenomena driven by supersonic, flowing plasma, but only recently have laboratory experiments begun to study such phenomena.[1] 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.[2] These experiments, performed on the Nova laser, are designed[3] to 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. The ejecta/foam interface is hydrodynamically unstable. We observe this hydrodynamic assembly by x-ray radiography.

In this presentation, we will discuss recent experiments to study hydrodynamic instabilities. We will describe the experimental package that we designed to obtain the best possible data. We will show the data and discuss the observed evolution of and structure of the unstable layer. To the extent they are available by the time of the meeting, we will also show simulation results from a laboratory simulation code and from an astrophysics simulation code.

(Work supported by the US Department of Energy and the University of Michigan.)

1. R.P. Drake, S.G. Glendinning, K. Estabrook, B.A. Remington, R. McCray, R. Wallace, L.J. Suter, T.B. Smith, R. London and E. Liang, *Phys. Rev. Lett.* **81**, 2068 (1998).
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3. R.P. Drake, J.J. Carroll, K. Estabrook, S.G. Glendinning, B.A. Remington and R. McCray, *Ap. J. Lett.* **500**, L157 (1998).

ORAL SESSION 5

Physics of Direct Drive

Andrew Schmitt, Chair

Wednesday, June 16th, 1999

Imaging of Compressed Shells with Embedded Thin, Cold, Titanium-Doped Layers on OMEGA

V. A. Smalyuk, F. J. Marshall, D. D. Meyerhofer, and B. Yaakobi

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Abstract

The compressed shell integrity of spherical targets has been studied using the 60-beam, 30-kJ UV OMEGA laser system. The emission from the hot core has been imaged through the thin, cold, titanium-doped layer within the target shell. Images of the target have been obtained using a pinhole-array x-ray spectrometer. We measured nonuniformities in core emission using target images taken at energies below the titanium *K*-edge. Images taken at energies above the titanium *K*-edge contain information about areal-density nonuniformities in the cold, titanium-doped layer inside the target shell. Comparing target images below and above titanium *K*-edge, the imaging-system noise and areal-density nonuniformities in the titanium-doped layer have been characterized. Using this method we investigated the compressed shell integrity of spherical implosions by varying the position of the titanium-doped layer within the shell and by using two different laser pulse shapes. With 1-ns square pulses, no shell structure has been observed with a resolution of 16 μm.

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.

Prefer oral session

29^{th} Annual Absorption Conference

A Plasma Piston for Radiation Hydrodynamics Experiments

J Edwards, S G Glendinning, L J Suter, T D Shepard, R E Turner, K S Budil, B Lasinski, A S Wan, and B A Remington, LLNL

P Graham, A M Dunne, B R Thomas, AWE

A new class of source is being developed for studying compressible hydrodynamic instabilities in systems driven by an admixture of material pressure and X-ray ablation. One such source consists of half a scale 1 Nova hohlraum, 1.6 mm in diameter and ~ 1.55 mm in length. The open end is filled with a ~ 0.15 g/cc CH foam slug, ~ 300 μm in length, with the experimental payload mounted at the end of this. The hohlraum is driven from the other end by 5 Nova beams delivering ~ 12 kJ of energy in a 1ns pulse, generating a radiation temperature ~ 200 eV which drives a supersonic, M_R~3, radiation wave down the foam. Radiation penetrating the foam ablates the package, which is subsequently driven by a combination of the X-ray ablation, and the material pressure provided by the hot foam. The relative importance of each mechanism can be controlled by the target design, drive, and foam density. It is possible to span from the freely ablating to the strongly tamped regime, in which the kinetic pressure of the foam is the dominant drive mechanism. This is clearly demonstrated in the Nova experiments. The payload in these experiments consisted of a thin, 1/2 μm, gold layer, supported on a 10 μm thick CH foil. After the shock wave has traversed the payload, the hot foam plasma acts like a piston, accelerating the package away. In this particular design, the payload is largely penetrated by the radiation so ablative effects are minimal after an initial phase. The density discontinuity between the foam and gold, together with the acceleration, drives the classical Rayleigh-Taylor instability, seeded by non-uniformities in the foam imprinting on the gold. The experimental data will be presented and discussed, together with a theoretical framework for this new regime, and detailed 2D numerical simulation of the target dynamics including the foam-seeded instabilities. It is planned to continue experiments on the Omega laser to study the ablative Rayleigh-Taylor instability in this regime. Concepts and exploratory experiments will be presented.

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F3d Simulations Of The Propagation Of Nova Beams In Gas-bag Targets.

Edward Williams

E. A. Williams, A. B. Langdon, C. H. Still, R. L. Berger and S. N. Dixit
Lawrence Livermore National Laboratory

LLNL

Abstract

We use the massively parallel version of the laser-plasma interaction code F3D(1) to model the propagation of a Nova interaction beam through a gas-bag plasma. We model the incident laser beam making use of measured phase-front data and the characteristics of the KPP/SSD beam-smoothing. We simulate the entire beam cross-section so that both whole-beam and speckle physics are accounted for.

Our physics model includes the paraxial propagation of the laser light and its ponderomotive and thermal interactions with the fluid plasma. The beam propagation is subject to thermal and ponderomotive self-focussing, filamentation and forward Brillouin scattering. It is not yet feasible to include the effects of backward SBS and SRS on this scale of simulation.

The plasma conditions are obtained from LASNEX simulations.

(1) R. L. Berger et. al., Phys. Plasmas 5, 4337 (1998)

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29th Annual Anomalous Absorption Conference

Progress for the parallel LPI design code pF3d*

Bert

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Real code jock.

Over the past few years, aggregate computing power and memory available on massively parallel processors (MPPs) have risen dramatically. To take advantage of the increased resources and to move towards attaining a predictive LPI capability for NIF, we began building pF3d, a parallel version of the laser-plasma hydrocode F3D. Coupling the increased resources with recent advances in algorithms and modeling capabilities, we have begun simulating laser-plasma interactions in plasma volumes approaching the size of a single NIF beam using pF3d. We report on recent developments with pF3d and present some results of simulations involving LPI in single NIF beam sized plasma volumes.

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

The Role of Hot Electrons and Langmuir-Decay Instability on the Development and Saturation of Stimulated Raman Scattering

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Considerable experimental evidence is accumulating to show that the Langmuir decay instability (LDI) plays an important role in the saturation of stimulated Raman scattering (SRS). Furthermore, evidence for LDI cascade and Langmuir collapse have been observed experimentally in the saturation of other parametric instabilities. Fluid models of the Zakharov form have been utilized successfully to describe experimentally observed features of LDI cascade and collapse. In spite of this considerable success, it is commonly understood that the Zakharov model suffers from certain deficiencies relating to the manner in which the excited waves are damped and due to its limited treatment of higher order nonlinearities. However, the quantitative significance of these shortcomings cannot be assessed within the context of a strictly fluid treatment. Some of these limitations can be assesed by the use of a recently developed hybrid model, ODYSSEUS, in which the ions are treated as finite-size particles and the Langmuir waves are treated using a modified Zakharov model which accounts for changes in the spatially averaged electron distribution function by means of the quasilinear diffusion model. Although ODYSSEUS is a significant improvement over the standard Zakharov model, it does not account for: (a) electron trapping, (b) Langmuir wave generation by hot electrons which, in turn, are generated by SRS, and (c) dissipation of Langmuir waves by non-resonant electrons. These limitations can be surmounted with the use of reduced-description particle-in-cell (RPIC) simulations.

In this presentation, these three plasma simulation models (standard Zakharov, ODYSSEUS, and RPIC) are compared for the case in which parametric instabilities are driven by a laser pump. It is shown the hot electrons, even in modestly driven systems, can affect the development and saturation of SRS. In particular, the spectral width of the Langmuir wave spectrum and the number of LDI cascade is a sentsitive function of the number of hot electrons. Also, the Langmuir wave level generated by such hot electrons are significant compared with that generated by SRS.

29th Annual Anomalous Absorption Conference

Laser-Plasma Interactions in the 350 eV National Ignition Facility Target*

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Design is underway on the 350 eV hohlraum target for National Ignition Facility (NIF) applications. A radiation temperature of 350 eV is achieved with NIF, where maximum power is ~ 700 TW and maximum energy is 1.8 MJ, by reducing the hohlraum size to 75% that of the 300 eV design, and by reducing the capsule size to 65% that of the 300 eV design. One-dimensional simulations show a yield of 5.8 MJ. The yield is lower than in the 300 eV design because of the relatively smaller fuel mass.

At a peak power of 600 TW with 1.4 MJ of total energy, two-dimensional integrated simulations of this target show a yield of 5.4 MJ when radiation symmetrization is imposed. Optimizations such as lowering peak power, increasing the spot size in an effort to reduce the peak intensity, slightly increasing the hohlraum gas fill density and decreasing the case-to-capsule ratio will be presented and discussed. Also initial assessments of the Rayleigh-Taylor stability of this target will be presented.

Along the NIF outer beam the electron temperature is fairly constant at about 6 keV; along the inner beam, it is about 6 keV near the laser entrance hole (LEH), and drops off as the hohlraum wall is approached. The ion temperature is 1.5 keV over most of both beam cones. The electron plasma density is about one-tenth to two-tenths critical density for most of the beam path, from the LEH to the hohlraum wall. Both the Brillouin and Raman backscatter are nonlinearly high at peak power. Simulations using the parallel version of F3D (pF3D) show that an f/8 RPP beam filaments under plasma conditions such as those at the LEH. Application of 6Å of SSD to the RPP beam begins to control the filamentation. RPP beam results with SSD and polarization smoothing will be presented.

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

Quasilinear Transition From Compton To Raman Scattering

C.S. Liu and Vipin Tripathi

University of Maryland

The Compton backscattering of laser radiation by the plasma quasi mode near the electron thermal speed leads to plateau formation of the electron distribution at the resonant velocity. This flattened distribution permits the weakly damped plasma wave to exist even with phase velocity near the thermal speed. This plasma wave can cause a stronger Raman scattering.

ORAL SESSION 6

ULTRA-INTENSE, SHORT PULSE LASER INTERACTIONS

William Kruer, Chair

Wednesday, June 16th, 1999

The Dependence On The Density Scale-Length Of The Directionality Of The Electron Beam And The Generation Of Ultra-Large Magnetic Fields In Relativistic Laser Plasmas

P.A.Norreys[1], R.Allott[1], F.N.Beg[2], E.Clark[2], R.J.Clarke[1], A.E.Dangor[2], K.Krushelnick[2], K.W.D.Ledingham[3], A.Machacek [4], T.McCanny[3], D.Neely[1], M.Santala[2], R.P.Singhal[3], I.Spencer[3], M.Tatarakis [2], J.S.Wark[4], I.Watts[1], S.C.Wilks[5] and M.Zepf [2]

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The invention of the technique of chirped pulse amplification has allowed unprecedented intensities on target to be reached. At the same time, new applications of this technology have been proposed that hold great promise for the future. These include laser induced radionuclide production as well as the fast ignition scheme for inertial confinement fusion. A determination of the effects of the different absorption processes on the electron temperature and the directionality of the electron beam under controlled conditions is therefore of great importance. In this paper, novel measurements of the angular distribution of bremsstrahlung gamma-rays (produced by the deceleration of relativistic electrons in high Z solid targets) using photo-neutron reactions in copper will be presented. It will be shown that the gamma-ray beam is highly directional and moves from opposite the target normal direction to the laser k-vector direction as the scale-length is increased from L ~ 1 micron to L ~ 7 microns. It will also be shown that for very large scale-length plasmas, the gamma-ray beam direction is random, supporting results obtained with the NOVA PWatt laser. In addition, unique measurements of magnetic fields in the high density plasma will be presented. Both the Cotton-Mouton effect and high energy particle deflection were used to determine the magnitude and structure of magnetic fields generated during high intensity interactions (I ~ 1e19 W/square cm). This data suggests that such fields are on the order of 100 MG or greater.

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Laser-driven Nuclear Fission, Positron Creation and Electron Acceleration in Ultra-Intense Laser-Solid Experiments on the Petawatt

T.E. Cowan, A.W. Hunt, J. Johnson, M. Roth, C. Brown, W. Fountain, S. Hatchett, E.A. Henry, J. Johnson, M.H. Key, T. Kuehl, T. Parnell, D.M. Pennington, M.D. Perry, T.C. Sangster, M. Singh, R. Snavely, M. Stoyer, Y. Takahashi and S.C. Wilks

The LLNL Petawatt Laser has achieved focussed intensities well in excess of 20 W/cm^2, which has opened a new, higher energy regime of relativistic laser-plasma interactions in which the quiver energies of the target electrons exceed the energy thresholds for many nuclear phenomena. We will describe recent experiments in which we have observed electrons accelerated to 100 MeV, photo-nuclear fission, and positron-electron pair creation.

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

Energetic Particle and Photon Production with Ultra-Intense Lasers

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

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There is abundant experimental evidence for the production of large amounts of relativistic electrons, ions, neutrons, and high-energy photons when a short, high-intensity laser pulse is incident on a solid target.

We used the 2D relativistic parallel Particle-In-Cell code MANET to study the microscopic physics underlying these phenomena. The code diagnostics include, among others, electron and ion distributions. These can be post-processed to yield neutron and x-ray photon productions expected for various kinds of target materials (deuterated, high or low-Z substrates...). We made a special effort to compare our results with experimental data obtained on the P102 facility at CEA/Limeil and elsewhere. We also extrapolated to what could be achieved with Petawatt-class lasers.

Fusion neutron spectroscopy as a diagnostic tool for relativistic laser-plasma interaction

S. Karsch, G. Pretzler, D. Habs, M. Gross, U. Schramm, P.G. Thirolf and K.J. Witte

Universitaet Muenchen

The interaction of an ultraintense laser pulse with an underdense plasma leads to the formation of a light channel and to the acceleration of electrons and ions to high energies, as has been investigated experimentally and theoretically by several groups. While electron and x-ray emission from the channel has been studied in detail, the spectral and angular distribution of the emitted ions has not been investigated extensively. From theoretical work one expects the ions to be accelerated predominantly in sideways direction, as follows from a coulomb-explosion-like channel expansion. Their energies range from the 100 keV to MeV region. Our experiments are designed to shed light onto the ion acceleration mechanism. In order to circumvent the possible severe disturbance of the primary ions due to the high fields present in relativistic plasmas, we investigate the angular and spectral distribution of fusion neutrons from the reaction d(d,n)3He . They carry information about the ion velocity distribution, but are not influenced by the strong fields. In our experiments, 5 TW pulses from a 10 Hz Ti:Sapphire laser are focused into a deuterium plasma at intensities of 3 x 10^18 W/cm^2 . Ions are accelerated to sufficient energies to undergo fusion reactions. We present neutron energy spectra derived from time of flight measurements under various experimental conditions, and discuss how to recover angular and energetically resolved ion distributions from these spectra.

29th Annual Anomalous Absorption Conference
13-18 June, 1999

Fast Ignition Studies using Ultra-Intense CPA Lasers at ILE, Osaka University

Yoneyoshi Kitagawa
Osaka University
Institute of Laser Engineering
Suita, Osaka, Japan

Yoneyoshi Kitagawa, Ryosuke Kodama, Kazuo Tanaka, Hisanori Fujita, Kunioki Mima, Tastuhiko Yamanaka, Takayoshi Norimatsu, Nobuhiko Izumi, Jun Sunahara, Yasuhiko Sentoku, Kenjiro Takahashi, Hideaki Habara, Michiaki Mori, Tomohiro Matsushita, Tatsuya, Sono*

Using two CPA high power lasers, one of which is 60TW GEKKO XII PWM laser and the other is 40TW GEKKO MII laser, we have performed laser plasma interaction studies on the fast ignition. It includes the transport, self focusing, filamentation, and scattering of laser; high energy electron generation, transport, deposition and jet formation; high energy ion generation, nuclear reaction and neutron generation.

The 60TW PWM laser was completed last year as the 13th beam to the GEKKO XII twelve beam system. The system is glass oscillator+Ti:Sapphire regenerative+glass amplifier hybrid one, providing 45J on target in 800 fs (FWHM) at 1053 nm. 25% of the total energy is focused within 8.8 mm spot. The prepulse is ~10-4 the main peak. 100 ps green RPP beams from The GEKKO XII illuminate a target about 1ns prior to the PWM shot, producing a long scale preplasma. While, the 40 TW GMII CPA laser is also completed as a Ti:sapphire front end +glass amplifier hybrid system, providing 18 J on target in 500 fs (FWHM) at 1053 nm. The prepulse is 2x10-4.

When and only when we focused the PWM few tens mm outer a critical density, we observed an bright spot, close to the solid surface and much smaller than the focal size. A characteristic jet is followed from the spot.

We observed fundamental, second and three-halves backscatterings, to understand the laser transport from a quarter critical to over critical region as well as a filamentation. New devices are equipped to detect and analyze hot electron spectrum and transport to the rear side of the target. Generation mechanism of high energy ions and neutrons are investigated.

Theoretical efforts are made for the fast ignition study as well as PIC simulations.

Experimental studies of tabletop laser driven deuterium cluster fusion.

J. Zweiback, V.P. Yanovsky, T.E. Cowan, G. Hays, K.B. Wharton, T.Ditmire

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Abstract

Recently it has been shown that when clusters of deuterium atoms are irradiated with intense, femtosecond laser pulses, conditions can be created which are sufficient to fuse deuterium atoms, producing DD (2.45 MeV) fusion neutrons. This is the most recent work studying the interaction of high intensity short-pulse lasers with atomic clusters. Previous work has shown that cluster targets can almost totally absorb the incident laser energy, transferring a majority of the energy to ion kinetic energy. This efficient coupling is due to a resonance effect from the cluster boundary. The high ion energies which are created when the clusters explode, coupled with high average ion density ($>10^{18}$ /cm^3), produce conditions for fusion in the inertially confined plasma. We have observed $>10^4$ neutrons/shot using 100 mJ, 30 fs laser pulses. We will present recent experimental results and discuss the physical processes behind laser-cluster interactions, as well as ideas for future scaling of fusion yield.

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13-18 June 1999

Laser-driven Micro Neutron Sources For Fusion Material Irradiation At High Flux And Fluence

L. John Perkins

L. J. Perkins, B. G. Logan, T. Ditmire, P. T .springer, S. C. Wilks, M. D. Rosen, M. D. Perry, T. Diaz Dela Rubia, N. M. Ghoniem

LLNL

Abstract

Modern high-intensity lasers have the potential to drive low cost, D-T point neutron sources for fusion materials testing at high flux/fluence. This offers the intriguing possibility of the near-term realization of a high yield neutron test facility for fusion materials research with only modest capital outlay of <$100M, i.e. an order-of-magnitude less than any other candidate fusion irradiation facility.

Today, access to high temperature states of matter capable of thermonuclear fusion and the efficient production of hot ions for beam-target fusion is now within reach using modest-scale, bench-top lasers. These offer sufficient energy density for efficient neutron production in DT targets with dimensions of around a few-100microns. Close-coupled material test specimens would be ~1mm in length within a high-flux volume of ~1cm3.

Four target concepts are under study – an exploding foil beam-target system, a high-intensity shock-driven target, an exploding-pusher target, and a cluster-ion gas target concept. We will report on our initial modeling studies that indicate that a laser driver with ~100J-1kJ/pulse at 10-100Hz (~10kW average power) and intensities in the range 10^17-10^19W/cm2 could produce primary, uncollided 14MeV neutron fluxes at the 1mm test specimens in the range 10^14-10^15 n.cm-2s-2.

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Experimental Measurements of Deep Heating Generated by Ultra-Intense Laser-Plasma Interactions*

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An understanding of suprathermal electron production, transport and energy deposition in ultra-high-intensity (> 10^{18} W $\mu m^2/cm^2$), short-pulse laser experiments is vital in diverse areas of research including the Fast Ignitor concept for Inertial Confinement Fusion. In this paper, we describe the results of experiments in which we used x-ray plasma spectroscopy and x-ray imaging of thin Al tracer layers buried in plastic to diagnose deep heating generated by target interactions with a 500 J, 5 - 20 ps, 0.5 - 2 x 10^{19} W $\mu m^2/cm^2$ laser. We measure temperatures in excess of 300 eV at near-solid densities for depths as great as 30 μm from the target surface. In addition, the x-ray images typically show annular rings of emission with diameters up to an order of magnitude larger than the laser spot diameter. We discuss several possible explanations for these results.

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

ORAL SESSION 7

NOVEL APPLICATIONS

Peter Amendt, Chair

Thursday, June 17th, 1999

29th ANNUAL ANOMALOUS ABSORPTION CONFERENCE

Guiding large-scale electrical discharges with ultrashort laser pulses

Bruno La Fontaine, Daniel Comtois, Ching-Yuan Chien, Alain Desparois,
Tudor Johnston, Jean-Claude Kieffer, François Martin, Raafat Mawassi, Henri Pépin,
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Carl Potvin, Pierre Couture, Hubert P. Mercure
Institut de Recherche d'Hydro-Québec – IREQ
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Abstract

In an effort to determine whether ultrashort laser pulses could be used to trigger and guide lightning, we are studying how plasmas produced with such lasers affect the dynamics of electrical discharges in air.

Using the non-linear propagation properties of ultrashort laser pulses in air, we created ionized filaments that served to guide, for the first time, electrical discharges over more than 2 meters. With laser pulse energy of 20 mJ to 150 mJ, these filaments could guide *streamer*[1] discharges where the electric field was fairly uniform and had an average value of 0.5 MV/m. Such a guiding effect was observed for times of up to ~10 μs after the laser pulse created the ionized filaments.

Images of the early stages of the discharge show that the laser-produced ionized filaments act as preferred streamer channels that are subsequently heated by the streamer corona. These straight conductive channels then carry the arc current as the voltage in the gap breaks down.

Additional work on the triggering and guiding of electrical discharges dominated by the *leader*[2] mechanism is required in order to properly assess the effectiveness of this technique.

1- A *streamer* is a wave of ionization leaving a cold channel along its path.
2- A *leader* is a heated streamer channel with high electrical conductivity.

ORAL PRESENTATION
To be associated with companion presentation : *Triggering of large-scale..... laser pulses*

29th ANNUAL ANOMALOUS ABSORPTION CONFERENCE

Triggering of Large-Scale Electrical Discharges using Ultrashort laser Pulses

Henri Pépin, Daniel Comtois, Ching-Yuan Chien, Alain Desparois,
Tudor Jonhston, Jean-Claude Kieffer, Bruno La Fontaine, François Martin,
Rafaat Mawassi, Farouk A.M. Rizk, François Vidal
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Carl Potvin, Pierre Couture, Hubert Mercure
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Abstract

Lasers are a promising tool to trigger and channel lightning strikes. In this context, Hydro-Québec and INRS have undertaken a feasibility study of laser triggered-lightning using ultrashort laser pulses.
We will present results from a study of the triggering of *leader** discharges (gaps of 3 to 4 meters) by a laser-created plasma (laser pulse energy of 200mJ, pulse duration of 100 fs). The basic physical processes involved in the formation of *streamers* and in the *leader* growth have been observed using time resolved optical diagnostics, as well as electric field and current probes. Numerical simulations complement the analysis of the experimental data.

* *A leader is a conductive plasma channel that develops from streamers.*

ORAL PRESENTATION
To be associated with companion presentation : *Guiding of large-scale ......laser pulses*

29th Annual Anomalous Absorption Conference
13-18 June 1999

Experiments On A Radiative Collapse In Laser Produced Plasmas Relevant To Astrophysical Jet Formation

Ryosuke Kodama

R. Kodama, T. Koase, Y. Ochi, H. Nishimura, H. Azechi And H. Takabe
K. Shigemori, D. R. Farley, B. A. Remington, K. G. Estabrook

Institute of Laser Engineering

Abstract

We have experimentally studied a radiative collapse related to jet formation in astrophysics. The radiation effects plays an important role in the hydrodynamic evolution in the space such as a radiatively cooling jet formation.Å@This radiative jets were investigated by using laser-produced plasmas created with conical targets [1].

The experiments were carried out by using the GEKKO XII laser system at Institute of Laser Engineering, Osaka University. Conical targets (CH, Al, Fe and Au) were irradiated by 100 ps pulses of 0.53-mm laser light of 6 beams of the system at an average intensity of 5x1014W/cm2. Two dimensional x-ray images were measured with time integrated x-ray pinhole cameras, showing well-collimated jet structures . X-ray shadow gram was also obtained and high density regions appeared on the center axis of the jet. The time-evolution of the jet formation was measured with x-ray framing camera and x-ray streak cameras from different angles; one is for the time evolution of the longitudinal direction of the jet and another for the radial direction. We also changed the target material (CH, Al, Fe and Au) for the atomic number dependence and the laser intensity to examine the radiative cooling effect on the jet formation. All the data suggests that the radiative cooling is essential for the jet formation, i.e.a radiative collapse on the axis of the jet.

We will present the experimental results comparing with 2-D LASNEX simulations and discuss the astrophysical implications.

[1] D. R. Farley et al., submitted to Phys. Rev. Lett.; UCRL-JC-133046

Anomalous Heating by Intense Neutrino Fluxes in Astrophysical Plasmas*

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[(a)]Department of Physics and Astronomy University of California Los Angeles, Los Angeles CA 90095
[(b)]Rutherford Appleton Laboratory, Chilton, Didcot, Oxon OX11 OQX, U.K.
[(c)] Lawrence Livermore National Laboratory, Livermore, CA 94550

Abstract

Intense fluxes of neutrinos are associated with the most extreme events in the Universe, such as supernovae, gamma-ray bursts, and the lepton era of the early universe. In these scenarios even neutrino driven plasma instabilities can develop. The two fundamental issues associated with collective neutrino driven instabilities are the strong energy transfer from the streaming neutrinos to the background plasma, and the formation of plasma structures (e.g. filamentation).
We determine here the energy deposited by the neutrinos in the plasma due to the neutrino driven streaming instability (NUSI). The subsequent anomalous plasma heating is also the saturation mechanism of the NUSI. Our analysis is based on a set of coupled quasi-linear equations for the neutrinos and the plasma electrons, which are solved numerically for supernovae IIa parameters. Preliminary results indicate anomalous plasma heating up to 1 MeV/electron in time scales three orders of magnitude smaller than the star explosion time scale. Possible signatures of the NUSI in the emitted neutrino spectrum are explored. The impact of the anomalous plasma heating in SNIIa (in connection with the "stalled shock problem") is also discussed in the light of present models for the ejection of the outer layers of SNIIa. Analogies between neutrino and laser (photon) plasma interactions will be given.

*Work partially supported by DOE Contract no. DE-FG03-98DP00211, NSF Contract no. AST-9713234 and PRAXIS XXI-BPD/97.

29th Annual Anomalous Absorption Conference
13-18 June, 1999

Cale Simulation Of The Supernova Remnant Experiment

Omar
O. A. Hurricane
Lawrence Livermore National Laboratory
A-Division

The supernova remnant (SNR) experiment was designed to have structural and hydrodynamic features that mimic those of young SNR's [Drake, et al., Ap. J. Lett., 500, L157, 1998]. In the experiment, the x-ray flux (supernova explosion) drives plastic (the stellar envelope) across a vacuum gap (space) into a low density foam (the interstellar material). After the radiative shock drives some of the plastic into the foam, instability develops at the plastic-foam contact surface. CALE successfully predicts many of the features seen in the experiment such as the gross amplitude vs. time development of the instability, the formation of Kelvin-Helmholtz like roll-ups at the edges of the contact discontinuity, the insensitivity of the instability amplitude to the initial perturbation on the foam, and the development of multiple mode harmonics at the contact discontinuity. One outstanding problem in the relative spacing between the plug remant and the contact discontinuity; this spacing appears to sensitively depend upon the time development of the gold plasma pressure in the holraum. All of these preliminary results will be discussed.

29th Annual Anomalous Absorption Conference
13-18 June, 1999

Cale Simulation Of The Supernova Remnant Experiment

O. A. Hurricane
Lawrence Livermore National Laboratory
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The supernova remnant (SNR) experiment was designed to have structural and hydrodynamic features that mimic those of young SNR's [Drake, et al., Ap. J. Lett., 500, L157, 1998]. In the experiment, the x-ray flux (supernova explosion) drives plastic (the stellar envelope) across a vacuum gap (space) into a low density foam (the interstellar material). After the radiative shock drives some of the plastic into the foam, instability develops at the plastic-foam contact surface. CALE successfully predicts many of the features seen in the experiment such as the gross amplitude vs. time development of the instability, the formation of Kelvin-Helmholtz like roll-ups at the edges of the contact discontinuity, the insensitivity of the instability amplitude to the initial perturbation on the foam, and the development of multiple mode harmonics at the contact discontinuity. One outstanding problem in the relative spacing between the plug remant and the contact discontinuity; this spacing appears to sensitively depend upon the time development of the gold plasma pressure in the holraum. All of these preliminary results will be discussed.

29th Annual Anomalous Absorption Conference
13-18 June 1999

Helicon sources as laser targets

F.F. Chen
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Electrical Engineering Department

Research on helicon RF plasma sources for semiconductor etching has revealed some very interesting physics about how these sources achieve their unusual efficiency. On the basis of our understanding, we can extrapolate to sources that will produce 10^15 cm-3 densities in an arbitrarily long column using no internal electrodes and relatively low RF power per meter length. Such a source might have accelerator applications.

ORAL SESSION 8

ULTRA-INTENSE, SHORT PULSE LASER INTERACTIONS

Peter Norreys, Chair

Thursday, June 17th, 1999

'Frustrated' Debye shielding as an explanation of satellites to higher harmonics generated in intense laser-plasma interaction

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Department of Physics, University of Toronto

R. Wagner, T. Maksimchuk, D. Umstadter
Center for Ultrafast Optical Science, University of Michigan

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Department of Physics, University of Texas at Austin

R.P. Drake
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Moderately high resolution spectroscopy has shown that mid- and higher-harmonic lines produced from ultra-intense, sub-picosecond, high-contrast laser-solid interaction may have close-lying satellites accompanying the harmonic peaks. These appear as regular red- and blue-shifted Stokes-like lines. These have been observed in experiments using the T^3 laser at the Center for Ultrafast Optical Science at the University of Michigan, in which we used intensities up to a few times 10^{18} W/cm^2, and pulse-to-prepulse contrasts better than 10^{10}, to systematically investigate these satellites, and the effect of plasma scalelength on them.

Their systematic frequency shift of 7.4×10^{13} rad/s is about 1.8 times the nominal frequency of a pure ion-wave associated with electron critical density. We speculate that we can now explain this as the result of 'frustrated' Debye shielding at high intensities: a breakdown, for ultra-intense laser-plasma interaction, of the Debye shielding which normally couples ion fluctuations as ion-acoustic waves under these conditions.

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Observation And Discussion Of Optical (3/2) Scatter In Ultra-high Intensity Laser-solid Interactions

Anton Machacek

A. C . Machacek, D. M. Chambers, J. S . Wark, I. Watts, M. Zepf, A. E. Dangor, E. Clark, K. Krushelnick, M. Santala, M. Tatarakis, P. A. Norreys, R. Allott, C. N. Danson, D. Neely, R. S. Marjoribanks

University of Oxford

Abstract

Diagnosing the plasma formed in current ultra-intense laser-solid interaction experiments is of paramount importance. Radiation emitted in the optical region of the spectrum can be a valuable diagnostic. However often the mechanism of generation is uncertain, and this limits the usefulness of the data.

We have consistently observed unusual optical scattering in the vicinity of the 3/2 harmonic, in the form of side peaks, which are only observed from ultra-intense (700fs) pulses. Intriguingly these are emitted from in only one direction– at right angles to the normal, and at 45 degrees to the incoming laser beam. These observations will be presented.

Secondly, we shall discuss the theoretical background to 3/2 harmonic emission in the quasi and fully relativistic regime; in particular investigating the effect of a short scale length and considering different mechanisms for the 3/2 production. This will be applied to the experimental data. Various constraints (for example, the satisfaction of conservation laws and dispersion relationships) are found to reduce the uncertainty of the production mechanism.

It is hoped that this work may lead to new diagnostic tools, or to further understanding of the part played by instabilities in, for example, reducing the efficiency of the fast ignitor.

Initial experiments on the JanUSP laser at focal intensities $>10^{21}$ Wcm^{-2}.

P.K. Patel, J. Bonlie, F. Patterson, D.F. Price, K. Widmann, S.C. Wilks, P.T. Springer

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Abstract

We present results from the first target experiments on the new 200 TW JanUSP laser at the Lawrence Livermore National Laboratory. The JanUSP laser is a 100 fs large aperture Ti:sapphire system, and has recently produced the highest focal intensity in the world at 2 x 10^{21} Wcm^{-2}. At this intensity the quiver energy of the free electrons in the laser field exceeds 10 MeV. Simulations performed with a 2D relativistic PIC code predict the generation of 100 Gbar ion shocks with ion velocities on the order of 0.02*c*. We will describe the characterization of the laser to date, including focal spot, pulse shape, and pre-pulse measurements, as well as future developments. We will also report on initial target experiments to characterize the hot electron and bremsstrahlung production above 10 MeV using photonuclear activation techniques.

This work was performed under the auspices of the US Department of Energy by the Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

Abstract Submitted to the
Anomalous Absorption Conference, Pacific Grove CA, 13-18 June 1999

Non-paraxial propagation of ultrashort laser pulses in underdense plasma

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Optical guiding of intense laser pulses in plasma channels [1] is beneficial to a variety of applications, including plasma-based accelerators, harmonics generation, x-ray lasers, and advanced laser-fusion schemes. In vacuum a laser pulse will diffractively expand after a distance on the order of a Rayleigh length $Z_R = \pi r_0^2/\lambda$, where r_0 is the laser spot radius at focus and λ is the laser wavelength. High intensity requires a tight focus (small r_0) and, hence, a small Raleigh length, e.g., $Z_R \simeq 300$ μm for $r_0 = 10$ μm and $\lambda = 1$ μm. A preformed plasma density channel can prevent pulse diffraction. The propagation characteristics of an ultrashort laser pulse in a preformed plasma channel are analyzed. The plasma channel is assumed to be parabolic and unperturbed by the laser pulse. Solutions to the wave equation beyond the paraxial approximation are derived that include finite pulse length effects and group velocity dispersion [2]. When the laser pulse is mismatched within the channel, betatron oscillations arise in the laser pulse envelope. A finite pulse length leads to a spread in the laser wavenumber and consequently a spread in betatron wavenumber. This results in phase mixing and damping of the betatron oscillation. The damping distance characterizing the phase mixing of the betatron oscillation is derived, as is the dispersion distance characterizing the longitudinal spreading of the pulse.

This work was support by the Department of Energy.

[1] For a review, see E. Esarey et al., IEEE J. Quantum Electron. **33**, 1879 (1997).
[2] E. Esarey and W.P. Leemans, Phys. Rev. E **59**, 1082 (1999).

Interaction Of Intense Laser Light With Super-Critical Density Plasma

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We have examined a number of aspects of the interaction of high intensity laser light with plasma at and above the critical density, N_c, using particle-in-cell codes. In particular we have investigated interactions at intensities generally above 10^{18} W cm^{-2} so that the electron dynamics is strongly relativistic and we have used in turn light that is linearly and circularly polarized and compared differences in the two cases. The general characteristics of light at such intensities propagating in dense plasmas are broadly understood as far as hole-boring due to strong ponderomotive effects are concerned. The detail of the interaction is usually more complicated. In many instances the critical density surface develops corrugations before breaking up into fragments. One important outcome of this fragmenting plasma is the subsequent penetration of the light between neighboring fragments of dense plasma, leading to the appearance of a strongly filamented plasma. Typically, the lateral dimension of the filaments and the spacing between them is about one wavelength. The subsequent nonlinear evolution of these structures shows a clear merging of filaments.

29th Annual Anomalous Absorption Conference
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Experimental evidence of a fast electron jet travelling through solid targets irradiated at relativistic laser intensities

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The final step of the Fast Ignitor concept consists in the rapid heating of a compressed DT core by a bunch of fast electrons generated by an ultra-high intensity laser pulse. Therefore, its success relies on the ability of an intense beam of energetic electrons to propagate with little angular spreading through several hundreds of microns at high density (ne>1e23cm-3). To test the validity of this scenario, an experimental run has been conducted on the LULI 100 TW laser facility. We will present time-resolved shadowgraphic measurements through transparent glass slabs showing very fast processes of energy transport inside the target. A remarkable result is the observation of a highly collimated(<30microns) jet propagating at the velocity of light and extending up to 500 microns. We think this is the long-awaited confirmation of a magnetically-assisted regime of electron transport. Another interesting feature is the existence of a hemispheric ionization front travelling at a somewhat slower velocity (around c/2) which appears to have a double radiative/electronic nature. A thorough understanding of these two coupled regimes requires an important numerical effort of which we will expose the first results.

Generation of Single Cycle Laser Pulses by Photon Acceleration

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University of California, Los Angeles

T. Katsouleas,
University of Southern California

Abstract

When a short-pulse laser propagates through an underdense plasma it generates a plasma wave wake. The laser pulse's energy decreases as the wake is generated while the number of photons, or equivalently, the classical action of the electromagnetic wave is conserved. If the pulse is shorter than a plasma period then the energy of each photon, $\hbar\omega$, gradually decreases; this is referred to as photon deceleration. Photon deceleration will continue until ω approaches ω_p at which time only a single wavelength of radiation is left. In addition, since the number of photons, E^2/ω, is conserved and ω is decreasing, then the normalized laser momentum, $p/(mc)=(eE)/(mc\omega)$, will increase despite the fact that E is decreasing. Therefore, this mechanism is also an $p_0/(mc)$ amplifier. We have observed this behavior in both 1D and 2D PIC (particle-in-cell) simulations for laser and plasma parameters, e.g., $n_0 = 4\times10^{19} cm^{-3}$, $\lambda_0 = 1\mu m$, $I = 10^{19} W/cm^2$, and $\tau_L = 15 fs$, which are now experimentally feasible. We will describe the physics of photon deceleration and present 3D PIC simulation results to determine whether photon deceleration can be used to generate attosecond pulses.

Work supported by NSF and LLNL.

INVITED TALK 3

High Intensity Laser Plasma Interactions
by
Don Umstadter
University of Michigan

Thursday, June 17th, 1999
Peter Young, Chair

High-Intensity Laser Plasma Interactions*

Donald Umstadter, Szu-Yuan Chen, Evan Dodd and Anatoly Maksimchuk
University of Michigan, Ann Arbor

Abstract

Recent experimental and theoretical results are presented on the interactions intense lasers with plasmas. Highlights include: (1) the direct observation of the figure-eight motion of electrons via relativistic nonlinear Thomson scattering, (2) the acceleration of electrons and highly charged ions into beams with multi-MeV energies and (3) coherent control of stimulated Raman scattering.

*Work supported by the National Science Foundation and the Department of Energy (Basic Energy Sciences and High-Energy Physics).

MIXED POSTER SESSION 3

Thursday, June 17th, 1999

Twenty–Ninth Annual Anomalous Absorption Conference
Asilomar Conference Center, Pacific Grove, California
13-18 June, 1999

The Two Plasmon Decay Instability in the Presence of Multiple Crossing Laser Beams

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We present the theory of the two-plasmon decay instability in inhomogeneous plasmas where the spatial structure of ISI laser beams is taken into account. The competition between transverse spatial variation of the laser beams on the one hand, and axial dephasing of the resonance and reduced coupling due to wave vector changes in inhomogeneous plasma on the other, is examined by using the Minimum Pump Strength Principle [B. B. Afeyan and E. A. Williams, A Variational Approach to Parametric Instabilities in Inhomogeneous Plasmas III and IV, Phys. Plasmas, 4, 3827 and 3845, 1997.]

Particular attention is paid to the changes in the mode structure of the most unstable modes when uniform transverse distribution of laser energy is assumed vs. the case with severe transverse localization of the laser intense spots. Hot spot distributions are treated which correspond to overlapping laser beams at different angles, both near and far from their turning points. The results are applied to an assessment of the conditions for the excitation or suppression of two-plasmon decay in promising target designs for inertial fusion energy.

*This work is performed under the auspices of the Naval Research Laboratory and the Department of Energy.

PREFER POSTER SESSION

Filamentation of smoothed laser beams in hot plasmas

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In gas-filled hohlraums used for indirect drive inertial confinement fusion, propagation of the laser beams in a mm-long hot plasma can be deviated, and their energy distribution as a function of time can be altered, by various nonlinar processes. Beam smoothing techniques producing fast and short patterns in the focal spot are intended to neutralize these mechanisms.

This study is concentrated on filamentation, which is modeled by the tri-dimensional paraxial code PARAX. This code couples three ingredients: a diffraction package which provides the realistic focal spot from a specified near-field pattern before focusing, a paraxial solver which propagates the beam under the competition of diffraction and refraction in the induced density modulations, and the linear hydrodynamics of the plasma represented by a damped ion-acoustic wave.

The results show various diagnostics of the filamentation, whose most important are the coherence time of the energy along the propagation distance and energy fraction above 5 times the average irradiance. Influence of the plasma drift velocity is considered, and the self-smoothing induced by the plasma is quantified. The efficiency of different smoothing techniques (RPP, SSD, Smoothing by Optical Fiber...) is compared.

Analysis and Simulation of Sound Waves Governed by the Ion-Fluid and Poisson Equations

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University of Rochester
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Abstract

The filamentation and SBS of laser beams have been observed in numerous ICF experiments. We are interested in how sound-wave nonlinearities modify the evolution of these instabilities. A standard model for nonlinear sound waves consists of the ion-fluid and Poisson (IFP) equations. In this model the electron fluid is assumed to respond adiabatically to the electric field produced by the motion of the ion fluid. We have written two codes to solve the IFP equations numerically. The first code is based on Fourier schemes, which require periodic boundary conditions. The second code is based on standard finite-difference schemes, which allow arbitrary boundary conditions. We use analytic solutions of certain limits of the IFP equations to check our simulations of linear dispersion and nonlinear steepening. The soliton solutions of the IFP equations are determined numerically and are compared to the soliton solutions of the KdV equation, which governs weakly nonlinear sound waves (McKinstrie and Kozlov, presented at this conference). When the initial shape of the wave packet is close to the soliton shape, the wave sheds a small amount of energy in the form of dispersive waves; otherwise it propagates stably for many soliton widths.

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.

Prefer Poster Session

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Stationary Laser Beam Filaments In A Semi-Collisional Plasma

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Recent investigations of laser-plasma coupling [1] have shown that the thermal collisional effects dramatically modify the plasma response even if the electron means free path is an order of magnitude larger than the size of laser filament. These conditions are typical for the laser filaments in a laser-produced plasma. Therefore, the nonlocal thermal effects due to the inverse Bremsstrahlung heating makes a significant contribution to the effective laser driving force which is different from the well-known ponderomotive force. The nonlocal transport effects have already been recognized to be important for the laser beam filamentation [2,3].

In this presentation we consider formation of a stationary laser filament using a nonlocal relation between laser intensity and plasma density perturbation (nonlocal laser-plasma coupling coefficient). Such a relation has been derived recently in a Fourier representation in the nonlocal transport theory of laser heated plasma [1]. It is valid for a semi-collisional plasma and has proper asymptotics which correspond to the well-known ponderomotive nonlinearity in a collisionless limit and to the thermal nonlinearity in a regime of frequent collisions.

This new expression for nonlocal coupling coefficient has been used to derive nonlinear wave equation for laser electric field. It takes the form of nonlinear Shr\"odinger equation (NLS) with an integral nonlinearity. The localized axially-symmetric waveguide solution of the nonlocal NLS has been found and compared to that of a local NLS equation with a saturated nonlinearity. We demonstrate that even weak electron collisions where the electron mean free path is ten times of the laser filament diameter dramatically modify the laser channel profile due to the electron heating. As compared to the standard collisionless ponderomotive laser filament a laser-produced plasma density channel is strongly enhanced and characterized by wide-spreaded radial wings. Stability of these waveguide modes will be discussed along with their relation to the angular characteristics of the transmitted laser beam

REFERENCES

1. A. V. Brantov et al., Phys. Plasmas 2742 (1998); in press (1999).
2. E. M. Epperlein, Phys. Rev. Lett. 2145 (1990).
3. A. K. Lal et al., Phys. Rev. Lett. 78 670 (1997).

Interaction experiments with a fiber-smoothed laser beam at $2\omega_0$ on the Phébus laser facility : massive targets and He-gas* targets

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The effect of the fiber smoothing technique used on the Phébus laser[1] has been studied in the context of laser plasma instabilities. The backscattered light was analysed both at 148° with respect to the laser propagation and with the help of the full aperture backscatter diagnostic recently implemented on the target chamber. The laser was focused at f/4 on massive CH and Au targets. The experiment has been performed at $2\omega_0$ with three laser spectral bandwidthes ($\Delta\lambda$ = 1Å, 5Å and 12Å) ; the incident laser intensity on target varied from $4\mathrm{x}10^{14}$ to 10^{15} W/cm^2.

The energy and the time-resolved spectra of Raman backscatter (SRS) were measured at 148° and through the focusing lens, as well as the $2\omega_0$ reflected light (specular reflection and Brillouin backscatter (SBS)). The main results show :

– the $2\omega_0$ reflected light does not depend on neither the spectral bandwidth nor the laser intensity. The backscatter energy is higher from CH than from Au targets, and is strongly peaked in the backward direction ;

– as expected from previous experiments[2], the SRS energy fraction was rather low (< 1%) and 10 times lower with Au targets than with CH targets. The SRS emission angularly broadens as the laser intensity increases. The spectral bandwidth becomes mostly sensitive in the backward (180°) direction. The time-resolved spectra show that SRS mostly occurs in the low density regions of the plasma for the backward direction, contrary to what happens in near-backward (148°) direction.

These results will be analysed with the help of the post-processor Piranah. The filamentation is suspected to play a significant role -as usual- in these experiments ; in this context, we will also present preliminary results obtained by irradiating a preionized He-gas jet (density ~ 0.05 n_c), where SRS, SBS and self-Thomson scattering spectra in a near forward direction have been obtained.

[1]D. Véron *et al.*, Optics Commun. **97**, 259 (1993).

Theory of Thomson scattering spectra from laser produced plasmas*

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Thomson scattering is a powerful diagnostic of laser produced 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 several experiments involving different plasma conditions and geometries.

Our theoretical models assume stable plasmas with inhomogeneous hydrodynamical variables: temperature, flow and plasma density. We discuss the effect of ion and electron collisions on the dynamical form factor. The threshold condition for the return current instability driven by the temperature gradient is discussed. In particular we have derived a model of the fluctuation level in the plasma with a strong temperatures gradient in the regime of a nonlocal thermal transport. Comparison with experimental results illustrates the possibility of using Thomson scattering to investigate transport processes in plasmas.

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* *This work was partially supported under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48 through the Institute for Laser Science and Applications.*

Hard X-Ray Signatures for Laser–Plasma Instabilities on OMEGA

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Abstract

Laser–plasma instabilities producing an unacceptable high level of hot electrons are potentially dangerous for both direct-drive and indirect-drive laser fusion. The hot electrons preheat the fuel and prevent compression of the capsule to the requisite conditions for ignition.

Fast electron generation can be inferred from the hard x-ray radiation generated by the interaction of the hot electrons with the target and surrounding material. In addition, optical signatures, like 3/2 ω radiation for the two-plasmon-decay instability, can provide insight into the generation processes. Using the signals from both time-resolving and time-integrating scintillators, this paper will present an estimate of the amount and spectrum of the hard x-ray radiation, hence inferring the amount of laser energy coupled to suprathermal electrons and to the target.

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Prefer Poster session

Twenty-Ninth Annual Anomalous Absorption Conference
Pacific Grove CA
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Study of the Saturation of Stimulated Raman Scattering by Secondary Decays

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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.

We are making measurements of the potential product ion waves from EDI and LDI decay of the SRS langmuir wave pumped by 3ω and 2ω (351 and 527nm) beams 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 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.
*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.

29th Annual Anomalous Absorption Conference

A 3D PIC Code to Study Plasma Interactions with Ultra-High Intensity Lasers

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We are developing a modern massively-parallel three dimensional relativistic electromagnetic particle-in-cell (PIC) code with some unique features. Initial application will be to model laser plasma interactions at intensities up to 10^{21} W/cm^2. Parameters for the initial code applications will be guided by current Petawatt experiments at Livermore. Previous studies have focused on the hot electron generation and the associated complex phenomena in 2-D simulations in both the underdense and the relativistically overdense regime[1,2]. Our goals are to extend these studies into 3-D and also to larger 2-D runs which encompass both underdense and overdense phenomena in the same simulation. Early results will be presented.

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[1] B. F. Lasinski, *et al.*, Phys of Plasmas, in press (1999), and references therein.
[2] S. C. Wilks and W. L. Kruer, IEEE Journal of Quantum Electronics **11**, 1954 (1997) and references therein.

A Simple Electromagnetic Wave Solver for 1-D Hydrocodes

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For a planar stratified medium, the solution to Maxwell's equations are counter-propagating plane waves. The usual methods for numerical solution of the wave propagation for arbitrary medium spatial profile, angle of incidence and polarization are fraught with difficulties. This new approach employs transfer matrices to advance the electromagnetic field; one part, based on Snell's law, accounts for the change in the dielectric function of the medium, and the second part propagates the wave. Solutions for s- and p-polarized light reproduce analytic results. We present results from simulations of laboratory experiments using the HYADES radiation hydrodynamics code.

29th Anomalous Absorption Conference
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Time resolved X-ray spectroscopy of thin foil heated by 100fs, 10^{18} W/cm^2 laser pulse

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A key issue in the field of laser-matter interaction using very intense subpicosecond optical pulses is the understanding of the temporal dynamics of the electron density and temperature. We have performed experiments on thin foils under well controlled conditions at the Lawrence Livermore National Laboratory Ultra-Short Pulse laser (USP) to study the temperature and density characteristics of laser heated solids. To suppress the ASE effect, the laser was frequency doubled with a 1.5 mm KDP crystal. The doubling efficiency was controlled by measuring the spectra and the energy of the doubled laser light. To minimize resonance absorption, the experiment was conducted with S-polarized light with a peak intensity of 10^{19} W/cm^2 ($I\lambda^2 = 2\ 10^{18}$ Wμm^2/cm^2).

The X-ray emission was recorded using a new two Von Hamos crystal spectrometer coupled to the LLNL 500 fs resolution streak camera. The experimental set up allowed us to record the helium-like $1s^2$-1snp transitons Heα, β and γ of aluminum as function of time. Very thin (250 Å -750 Å) aluminum foil targets were used to decrease the effect of temperature gradients and minimize optical depth effects. The time resolved spectra shows an unexpected intense 'continuum' between Heβ and Heγ due to satellite line emission. Additionally, the 250 Å heated foil show a Heα line with an extended blue wing which has a short lifetime (~ 4 ps). The width of the Heβ and He γ as a function of time is used as a measure of the time dependent electron density. The results using will be presented and discussed.

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

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Investigation Of Laser Created Relativistic Plasma Channels By Ion Spectroscopy

Manuel Hegelich

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Abstract

When focusing ultra-intense laser pulses into a gas jet, relativistic effects in the resulting underdense plasma lead to the formation of a light-guiding plasma channel, extremely high electric and mag-netic fields and the acceleration of electrons and ions to high energies. Especially the electron emis-sion has been studied experimentally and the measured spectra are in excellent agreement with the results predicted by numerical simulations. These simulations show that ions are accelerated pre-dominantly in radial direction out of light channel in a kind of Coulomb explosion. The predicted energies range from 100 keV up to the MeV regime.
In contrast to the electron emission, the spectral and angular distributions of the emitted ions have not yet been investigated in detail. We present an experimental setup for measuring these ion spec-tra and discuss how the various measurable quantities as, e.g., angular distribution, energy spectra and ionization states of the ions provide new insight into the physical processes within the relativis-tic plasma. Further simulations indicate quasistatic electric fields up to several TV/m and magnetic fields as high as 100 MG in the channel region. Furthermore, a method is proposed to probe these fields directly with temporal and spatial resolution via the deflection of highly energetic ions. 3D-simulations in preparation of this experiment are presented. All discussed experiments will be per-formed at the MPQ ATLAS Ti:Sapphire laser facility which delivers focal intensities of up to 10^19 W/cm^2 at a repetition rate of 10 Hz. Upgrading of the experiments to the most powerful existing laser systems and possible applications for the produced ion bursts are also dicussed.

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Netron Spectroscopy For Study Of Ion Accelaration In Ultra Intence Laser Interactions With Polarization Dependence

Hideaki Habara

H. Habara, R. Kodama, N. Izumi, Y. Sentoku, K. A. Tanaka, Y. Kitagawa, K. Mima And T. Yamanaka

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Abstract

We obtained laser polarization dependence of neutron spectra to confirm the ion acceleration mechanism in ultra intense laser plasma interactions. The ultra intense (50-100TW / 0.5-1ps) laser irradiated obliquely deutrated plastic (CD) targets with two liner polarizations, i.e. S-polarization and P-polarization. The intensities on the target were changed from 1018W/cm2 to 1019W/cm2. Neutron spectra from the D-D nuclear reactions by ions accelerated toward the target inside were observed with neutron spectrometers consisted of plastic scitillaters from different angles. The spectra were compared with 3-D Monte-calro simulation to look for the momentum distributions of accelarated ions. The results suggest ions were accelerated to the target normal direction for both polarizations. The experimantal results were also consistent with the simulation results by a 2-D particle in cell code (PIC) indicating the ion acceleration with a static electric field by charge separation between ions and electrons in the period of laser irradiation.

Recent Advances in the Simulation of Ultrahigh Intensity Laser-Plasma Interaction

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Ultra-intense laser pulses incident on overdense targets are a source of fast-electron pulses that can carry Mega-Amps of MeV particles into the target. The angular and energy distribution of these electrons is altered by various (collisional and collective) slowing down and scattering processes. Experiments with solid targets devoted to X-ray production, or with long, low-Z plasmas as in the fast-ignitor scheme, require quantitative description of these processes.

We are currently developing Calder, a massively parallel Particle-in-Cell (PIC) code to study laser-plasma interaction in 2 and 3 dimensions. Calder has already been run on different platforms, in its scalar or parallel version : a SGI/Cray T3E, a DEC Cluster, and a network of SUN workstations. We will present the overall structure of the code, assess its performance and scalability (i.e. the efficiency of running parallel as the number of processors is increased) on these different platforms, present some preliminary results as well as our plans for the future, when still more computing power is available at CEA/DIF.

Another code, PÂRIS, has been designed to simulate the three-dimensional motion of electrons under the self-consistent magnetic field induced by the axial current during propagation. Collisions with target electrons are modeled by a Monte-Carlo method and collisions with ions by a friction force. The magnetic field evolution is modeled by a diffusion process that depends on the target resistivity. The competition between collisional processes and self-induced magnetic fields, which respectively defocus and focus the electron beam, is numerically studied. X-ray Bremsstrahlung radiation induced by the electrons is calculated.

29th Annual Anomalous Absorption Conference

Opacity Of An Underdense Plasma Slab Due To The Parametric Instabilities Of An Ultra-Intense Laser Pulse.

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Abstract

The interaction of ultra-intense laser beams with underdense plasma slabs has been investigated with two-dimensional particle-in-cell numerical simulations, showing a strong absorption and a correlatively low transmission. Energetic electrons in the multi-MeV range are produced. At very high intensities the plasma transparency is recovered. These results are interpreted in terms of the development of electron parametric instabilities in the self-consistently heated plasma. The comparison with recent experimental results and the relation to the fast ignitor concept are discussed.

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Resonant Coupling Between Surface And Interface Plasma Waves In High-density Sharp-edged Planar Or Spherical Plasmas Produced By Ultrafast Laser Pulses

Michele Raynaud

Joseph Kupersztych And Michele Raynaud

Commissariat à l'Energie Atomique

Abstract

We consider the interaction between an ultrashort laser pulse and a hot high-density sharp-edged laser-created plasma resulting either from a microstructured target (planar geometry) either from a granular one with a double-step density profile. It is shown that an electron plasma wave can be reonantly driven at the density jump between the two plasmas by the field of a laser-excited surface wave leading to additional ligh absorption. Different excitation regimes are studied depending on the wavelength and the geometry of the plasma. Particular attention is devoted to nonlinear processes regime owing to the possibility of generation of energetic electrons and emisssion of x radiation via bremsstrahlung.

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Observation And Interpretation Of The Angular Patterns And Characteristic Energies Of Relativistic Electrons Ejected From Petawatt Laser Targets

Stephen P. Hatchett

S. Hatchett, R. A. Snavely, M. Key, C. Brown, T. Cowan, G. Henry, B. Langdon, B. Lasinski, D. Pennington, M. Perry, T. Phillips, C. Sangster, M. Stoyer, S. Wilks

LLNL

Abstract

In recent experiments we have measured the angular pattern of ejected relativistic electrons by means of radiochromic film packages surrounding Petawatt Laser targets irradiated at 10^19 to 10^20 Watts/cm^2. The electron energy dependence of the pattern features is characterized by differential filtering between film layers. Features in the electron patterns include, a semi-collimated beam directed normal to the target back surface, single high energy beams oriented to back surface normal, beams propagating along target front surface, and multiple filamented beams propagating along the forward direction.

We discuss how the patterns and energies of the electrons depend on target material, laser energy, laser beam quality, angle of incidence and laser polarization. We also relate these electron distributions to the observed target gamma-ray patterns and spectra measured with large shielded TLD and nuclear activation arrays. Our results are interpreted in light of the self-consistent electric and magnetic fields generated in and around the targets.

Numerical Study of Linear Feed-out of Short-Wavelength, Rear-Surface Perturbations in Planar Geometry

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Abstract

The propagation of small, short-wavelength perturbations from the back to the front surface of a laser-accelerated planar foil is investigated numerically, the foil being considered as an ideal gas. The front surface is initially flat, while the back surface is rippled. After the initial shock reaches the back surface, the rippled reflected rarefaction wave propagates toward the front, transferring the perturbation from the back to the front surface. Once the ablation front becomes rippled, the Raleigh–Taylor instability is seeded and the perturbation grows exponentially in time. An approximate solution of the linearized compressible flow equations can be found when the ripple wavelength is longer than the thickness of the compressed foil, whereas numerical simulation is required to investigate short-wavelengh mode. A 2-D numerical model based on Lagrangian compressible fluid equations has been applied to study the evolution of the perturbation. The final amplitude's dependence on wavelength and target thickness has been investigated.

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.

Prefer Poster Session

Twenty-Ninth Annual Anomalous Absorption Conference
Asilomar Conference Center, Pacific Grove, Ca
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Direct-drive laser-fusion pellet designs for the NIF*

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Direct-drive laser fusion targets for the NIF differ substantially from high-gain reactor-scale direct-drive targets. Because of the lower available laser energy and lower gain requirements compared to reactor scenarios, NIF targets can be designed with higher adiabats for better stability. However, imprinting effects from the laser drive may become a more important contribution to hydrodynamic stability. We present designs that explore tradeoffs between stability and performance. Stability is analysed both with discrete linear mode 2D calculations combined with a Takabe-Haan type analysis as well as full nonlinear multimode FAST simulations[1].

[1] "*Computational modeling of direct-drive fusion pellets and KrF-driven foil experiments*", J. H. Gardner, A. J. Schmitt, J. P. Dahlburg, C. J. Pawley, S. E. Bodner, S. P. Obenschain, V. Serlin, Y. Aglitskiy, Phys. Plasmas **5**, 1935 (1998).

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

Poster Session Requested

Radiation Hydrodynamics Effects in Laser Irradiated Targets.*

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Radiation hydrodynamics phenomena in laser blow-off plasma were observed with an x-ray streak camera looking side-on at planar targets in Nike laser experiments. Plastic and gold coated plastic targets were irradiated with a two step laser pulse, where a 4-nsec foot of 3-15% amplitude was followed by a 4-nsec, 5×10^{13} W/cm^2 main pulse. The evolution of the blow-off gold plasma and the underlying CH plasma was clearly imaged, showing, among else, the dynamics of the Radiative Plasma Structures (RPS). These effects, as shown by our hydrocodes, are important for pellet design.

* This work is supported by the U. S. Department of Energy.

Calculations of the Pressure Tensor in 2-D Geometry in the Presence of Large Gradients and Magnetic Fields

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In a recent publication [1], a calculation was presented of the pressure tensor in a spherically symmetric plasma that included nonlinear contributions from the electrons when large temperature and density gradients are present in the plasma. In this poster talk, this calculation is extended into two dimensions, corresponding to the 2-D cylindrical geometry of a Z pinch, but equally of interest in the 2-D geometry of a non-uniformly illuminated ICF pellet. In this case, there are three (rather than one) nonzero components of the pressure tensor that must be calculated, and the transport coefficients contain important magnetic field dependences. Comparisons will be made of the classically calculated (linear) pressure tensor, which depends on gradients in the fluid velocity, to the (nonlinear) pressure tensor, which depends on the strength, for example, of the temperature gradient relative to the electron mean free path. The importance of these gradient terms will be demonstrated by means of calculations of the classical shock wave structure of a highly ionized titanium plasma for a variety of shock wave strengths.

Work sponsored by DTRA.

[1] K. G. Whitney, "Momentum and heat conduction in highly ionizable plasmas", Physics of Plasmas, **6**, 816 (1999).

Prefer Poster Presentation

Modeling Line Emission from Dopants in ICF Pushers

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Line emission from ICF implosions can be used to diagnose the temperature of the DT fuel and to provide an indication of the distortion in the fuel-pusher interface. We have reported the results of indirect drive simulations which include the effects of both angular dependence in the drive x-rays and the growth of surface imperfections due to hydrodynamic instabilities in earlier papers and compared those results to experimental data. In this paper we model line emission from trace amounts of titanium placed in the inner layers of the plastic shell of an ICF capsule. The amount of titanium emission in indirect drive capsules on the Nova and Omega layers is sensitive to the temperature profile near the interface between the fuel and the pusher. We consider the effects of the number of Rayleigh-Taylor modes included in the simulation and the spatial resolution of the numerical grid on the titanium line emission.

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

Recent ICF Double-Shell Capsule Implosions Results

R. G. Watt, Norman D. Delamater, Scott C. Evans, Peter L. Gobby, and William S. Varnum, Los Alamos National Laboratory

Double-shell capsules have been ignored for a number of years, because it was assumed they would be too hydrodynamically unstable to reach ignition and high gain at the low energies available from laboratory facilities. Because recent calculations indicate that double shell targets may provide an alternative, non-cryogenic path to ignition on NIF, experiments have been conducted at the NOVA and OMEGA lasers to study indirectly driven double shell implosions. Double shell implosions in both cylindrical hohlraums at NOVA and "tetrahedral" hohlraums (with significantly improved time dependent symmetry) at OMEGA, at a calculated convergence ratio (CR) of 38, show yields in the range of 1-2% of clean 1D calculations (YOC). Recent "tetrahedral" hohlraum implosions at Omega with several different target designs, intended to either shield the inner glass microballoon from Au M band preheat or to allow imaging of the compressed core, show improved YOC at lower CR in the range 23-32. The YOC for these capsules is at or above the top of the data range of single shell capsules at similar calculated convergence. Primary diagnostics in these implosions have been the neutron diagnostics available at both facilities, with compressed core imaging added in the recent experiments. Individual implosion data and comparisons between the NOVA and OMEGA double shell implosions, as well as available single shell data will be presented. Compressed core images from Omega will also be shown.

Poster Session.

29th Annual Anomalous Absorption Conference; Asilomar Conference Center, Pacific Grove, CA, June 13-18, 1999 **3P24**

A Superconfiguration postprocessor for M-shell spectroscopy of NLTE laboratory plasmas

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Abstract - A superconfiguration atomic physics package has been constructed for generating superconfiguration averaged quantities needed for computing radiative properties of M-shell ionized plasmas. Based on the superconfiguration concept and on the super-transition-arrays method (STA),[1,2] the model generates superconfiguration average-energies, collisional and radiative rates needed for a calculation of population kinetics. It calculates also the statistical shift and width associated with each possible radiative electron jump between selected superconfigurations. These last quantities are necessary for computing relevant spectral properties. All the previously mentioned quantities are stored on files readable by a multicell time-dependent collisional-radiative model such as TRANSPEC[3]. This last model is intended to work as a postprocessor to any 1D hydro-code.

We describe here the main characteristics of the superconfiguration atomic physics package and discuss the main approximations used for large scale simulations of M-shell emission from hot plasmas. These considerations are illustrated with the computation of the X-ray emission of a laser-produced Barium plasma.

1 - A. Bar-Shalom *et al*, *Phys. Rev. A* **40**, 3183 (1989).

2 - A. Bar-Shalom, J. Oreg, M.Klapisch, *Phys. Rev. E* **56**, R70 (1997)

3 - O. Peyrusse, *J. of Quant. Spectrosc. & Radiat. Transfer* 51 281 (1994).

ORAL SESSION 9

Indirect Drive & Laser Plasma Interactions

Cris Barnes, Chair

Friday, June 18th, 1999

29th Annual Anomalous Absorption Conference
13-18 June 1999

High-Convergence Implosions in Tetrahedral Hohlraums at OMEGA

J.M. Wallace, G.R. Bennett, N.D. Delamater, W.S. Varnum, R.G. Watt, K.A. Klare, J.A. Oertel, A.A. Hauer, T.J. Murphy, P.L. Gobby, D.C. Wilson, Los Alamos National Laboratory, S.M. Pollaine, R.E. Turner, Lawrence Livermore National Laboratory, R.S. Craxton, J.D. Schnittman, F.J. Marshall, W. Seka, C. Stoeckl, V. Yu. Glebov, Laboratory for Laser Energetics

High-convergence, single-shell capsule implosions are being investigated with the 60-Beam OMEGA laser system at the Laboratory for Laser Energetics, University of Rochester, in order to approach more closely NIF (National Ignition Facility) implosion conditions. An important goal is to understand the observed fall-off of YOC (measured neutron yield/one-dimensional, unmixed calculated yield) with increasing convergence ratio Cr (initial outer capsule radius/fuel radius at neutron production). The yield degradation has generally been attributed to non-uniform x-ray drive around the capsule, pusher-fuel mixing before or during neutron production, or some combination of the two. The current experiments employ the tetrahedral hohlraum, which has been shown to provide very uniform drive, with the idea of minimizing the effects of drive asymmetry so as to isolate the effects of mix, and any other degradation mechanisms.

A status report of this on-going activity will be presented. Experiments performed to date, including the various diagnostics, will be described. Comparisons of Theoretical Modeling and Experimental data will be presented. The current state of our knowledge will be summarized.

*Work supported by U.S. Department of Energy

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High-convergence implosion studies on the Omega laser with indirectly-driven vacuum hohlraums*

Peter Amendt, R.E. Turner, O.L. Landen, C. Decker, S.G. Glendinning, S.W. Haan, O.S. Jones, S.M. Pollaine, L.J. Suter, R. Wallace

Lawrence Livermore National Laboratory, University of California

&

D. Bradley, S. Morse, G. Pien, W. Seka, J.M. Soures

Laboratory for Laser Energetics, University of Rochester

Results of a follow up campaign to study high-convergence (15-20) implosions in indirectly-driven cylindrical hohlraums using the multi-cone geometry of Omega are presented. Measured surface roughness spectra for all targets enable a comprehensive assessment of the role of mix on target performance. The following suite of 10 atm DD-filled capsules was shot: (1) smooth 1% Ge-doped CH ablators with nominal dimensions (440 μm o.d., 30 μm thick shells), (2) 0.3 μm rms roughened capsules with 1% Ge-doped CH ablators, (3) undoped CH ablators with nominal dimensions, (4) smooth 1% Ge-doped CH ablators with small o.d. (400 mm), and (5) smooth 1% Ge-doped CH ablators with extra-small o.d. (370 μm). All targets contained 0.05 atm Ar in the DD fuel for x-ray imaging of the imploded cores. Primary and secondary neutron yields provide additional information on target performance. Comparison of the database with 2D radiation-hydrodynamics simulations along with implementation of the Haan mix model[1] shows good agreement in target performance. Understanding the mechanisms of target performance degradation at high-convergence provides added confidence in achieving ignition on the National Ignition Facility.

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

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[1] S.W. Haan, *Phys. Fluids B* **3**, 2349 (1991); S.W. Haan, *Phys. Rev. A* **39**, 8 2 (1989).

Abstract submitted for the 29th Annual Anomalous Absorption Conference, Asilomar , CA

Time Resolved Symmetry Measurements using the Reemission Ball Method

G. R. Magelssen, N. D. Delamater, S. Evans, Los Alamos National Laboratory, Los Alamos, N. M.; J. J. MacFarlane, PRISM Computational Sciences, Madison, WI.; N. Landen, G. Glendinning and P. Amendt Lawrence Livermore National Laboratory, Livermore, CA.

Measuring symmetry both along and perpendicular to the hohlraum axis will be important in evaluating the performance of NIF capsules. We will present NOVA experimental data and calculations of symmetry measurements made along the hohlraum axis on scale-1 gas-filled hohlraums. The calculational results are from a three-dimensional viewfactor code developed by MacFarlane. These results suggest that the Reemission Ball method can measure flux asymmetries at the 2 to 3 percent level. We will also present recent symmetry data from scale-3 NIF-like hohlraum experiments done on the OMEGA laser facility. Preliminary viewfactor and radiation-hydrodynamic calculations will be compared with the experimental results and some of the limitations of the reemission method discussed.

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Diagnosis Of Ignition Shots On Nif: How Will We Know What Happened?

Steven W. Haan

S. W. Hann, O. S. Jones, T. R. Dittrich, J. A. Koch, T. C. Sangster, M. J. Edwards

LLNL

Abstract

Simulations of failing ignition targets allow a detailed study of the diagnostics required for NIF ignition experiments. Simulated images in x-rays and neutrons, and simulated emission spectra in neutrons, x-rays, and charged particles will be presented and discussed. Ultimately, the goal is to tell as much as possible about why an ignition implosion failed, from the measurements that can be taken. This objective is being approached by constructing a matrix of possible observations versus possible failure modes. This information can be used to prioritize diagnostic instruments, and to set their specifications.

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Feasibility of HighYield/High Gain NIF capsules

L. Suter, B. VonWontergham, D. Munro, S. Haan, S. Pollaine, M. Tabak- LLNL

We can relate the quantity of x-rays absorbed by a NIF indirect drive ignition capsule, E_{cap}, to NIF laser energy, E_{NIF}, via $E_{cap} = \eta_{abs}\eta_{CE}\,\eta_{HR\text{-}cap}E_{NIF}$ where η_{abs} is the fraction of incident laser energy absorbed by the hohlraum, η_{CE} is the conversion efficiency of laser light into x-rays and $\eta_{HR\text{-}cap}$ is the fraction of generated x-rays which are actually absorbed by the capsule. Our original ignition "point designs" (circa 1992) were made energetically conservative to provide margin for uncertainties in η_{abs}, η_{CE} , $\eta_{HR\text{-}cap}$, and E_{NIF}. For NIF's nominal 1.8MJ the 150kJ point design requires $\eta_{abs}\eta_{CE}\,\eta_{HR\text{-}cap}$ = 8.3%. Because the point design's theoretical η_{CE} $\eta_{HR\text{-}cap}$ is 11%, we see that "margin" was built into the program. Since that time an extremely large collection of Nova and Omega experiments and their related analysis indicate that NIF coupling efficiency may be almost "as good as we could hope for". Experiments studying stimulated brillouin and raman backscattering in NIF "plasma emulators" imply that η_{abs} should be >90%. Complementary work examining hohlraum radiation environment shows x-ray production and capsule coupling to be very close to modeling. Quantitatively, we find that η_{CE} $\eta_{HR\text{-}cap}$ will be ~1.04+-0.12 of the coupling predicted by our simulations.

Given coupling close to simulations, can credibly explore targets which couple more of NIF's energy to an ignition capsule. In this paper we discuss designs in which we greatly increase absorbed capsule energy by a combination of modest improvements. These include: extracting more energy from NIF using a longer, lower power pulse shape matched to a 260eV design; reducing hohlraum wall losses with "cocktails"; allowing the LEH to "close" during the pulse to reduce hole losses; slightly increasing capsule:hohlraum-size; an overall increase in time scale further increasing the radiation fraction absorbed by the capsule. The net result is the prospect of designs which absorb as much as 26% of a 2.25MJ pulse (600kJ).

In addition to describing the overall energetics, we present results of 2D integrated simulations indicating that such targets might, in fact, work together with analysis of the detailed hohlraum radiation production and wall losses.

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Radiation Environment in Nonsymmetric NIF Hohlraums

O. S. Jones, L. J. Suter, M. M. Marinak, and G. D. Kerbel

During the startup phase of the National Ignition Facility (NIF) the laser geometry will not necessarily be symmetric. In particular, when the first cluster (one quarter of all the beams) is activated, there will be a need to do experiments on vacuum and gas-filled half hohlraums oriented perpendicularly to the NIF z axis. One of the uses for such experiments will be to create plasma conditions as close as possible to those expected in full-scale ignition hohlraums in order to verify that laser-plasma effects are being adequately controlled.

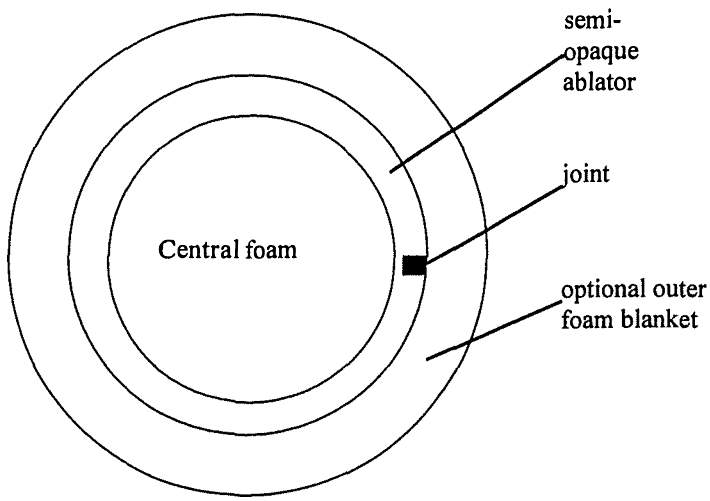
We have modeled such a hohlraum configuration using hydra, which is a three-dimensional radiation-hydrodynamics code. These calculations utilize laser ray-tracing and multigroup diffusion capabilities, which have recently been added to hydra. Details of the radiation drive environment for various configurations will be presented.

This work performed under the auspicies of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.

Probing Radiation Hydrodynamics Non-uniformities Due to Joints Through Cylindrical Implosions*

S. R. Goldman, Cris W. Barnes, K. Klare, Los Alamos National Laboratory, and
M. Dunne, P. Graham, B. R. Thomas, AWE, Aldermaston, U. K.

The use of cylindrical targets to explore the effect of joints on hydrodynamic structuring in ICF capsules has the advantage of including convergence effects while at the same time providing for transverse radiography with relatively uncomplicated determination of the density. Previous experiments have employed an optically thick marker layer at the inner radius of an optically thin ablator to probe interface structuring between the ablator and an inner foam cylinder due to the presence of a low density joint in the ablator.[1] As shown below, we have designed a target with semi-opaque ablator and no marker layer in an attempt to follow structuring away from the ablator – central foam interface. We will compare the shot data with simulations from the Rage and Lasnex codes to examine the following issues: shock propagation from the joint into the surrounding ablator, the resulting jetting of ablator material into the foam after the shock passes through the ablator – foam interface, and possible differences in shock structuring due to the difference between pure ablative pressure drive from X-ray deposition in the ablator and the partially hydrodynamic pressure drive caused by placing a foam blanket outside the ablator.



* This work was performed under the auspices of the U. S. Department of Energy by the Los Alamos National Laboratory under contract No. W-7405-Eng-36.

[1] M. Dunne, J. Edwards, P. Graham, B. Thomas, R. Smedley-Stevenson, C. W. Barnes, S. R. Goldman, W. Hsing, Bull. Am. Phys. Soc. 43, 1737 (1998).

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Hot Electrons From Two-plasmon Decay

David Russell

D.a. Russell And D.f. Dubois

Lodestar Research Corporation

Abstract

A 2D relativistic quasilinear extension of the standard model of TPD-driven turbulence in inhomogeneous plasmas is used to predict the spectrum of hot electrons generated by TPD. The parameters are appropriate for the Omega laser facility at LLE.

Three-Dimensional PIC Simulation of Laser-Plasma Interaction near Quarter Critical

F. S. Tsung, R. G. Hemker, C. Ren and W. B. Mori,
University of California, Los Angeles

Abstract

Laser-plasma interactions near the quarter-critical density are inherently three-dimensional. At this density in the plane subtended by the laser's E field and the wave vector, k, an electromagnetic wave can decay into an longitudinal wave, i.e., electrostatic plasma wave, and a wave with both longitudinal and transverse components; while in the orthogonal plane it can only decay into a plasma wave and a purely transverse wave, i.e., an electromagnetic wave. Therefore, to accurately model this mixture of the two-plasmon decay and stimulated Raman scattering instabilities requires 3D simulations. We have begun to study the process using 3D PIC simulations for parameters similar to those used in the work of Langdon et al. (Phys. Rev. Lett. **43**, 133-136 (1979)). We will begin by determining how efficiently high-intensity short-pulse lasers are absorbed at quarter-critical and how much energy ends up in multi-KeV electrons.

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Angular dependence of $3\omega_0/2$ spectra near the two-plasmon decay threshold*

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Abstract

The two-plasmon decay (TPD) instability remains an interesting phenomenon to study because, unlike the stimulated Raman and Brillouin scattering instabilities, it is localized near a known density ($n_c/4$) and so one would expect that the connection between experimentally observed spectra and modeling would have fewer unknowns. In most experiments, however, TPD spectra are normally observed in the presence of strong ion wave fluctuations which can rescatter the plasma waves, as evidenced by the isotropic nature of the observed spectra. In previous experiments [1], we were able to find a laser intensity regime near the TPD threshold intensity in which the observed TPD spectra did not show evidence of rescattering. In recent experiments in this regime, Thomson scattering measurements of the electron temperature and the flow velocity allow quantitative comparison of the angular dependence of the spectrum to linear theory. Scattered light at three-halves of the incident laser frequency from solid targets is observed at five different angles. The target is solid carbon and the laser intensity is near 5×10^{13} W/cm^2. Reduced–model simulations of TPD-driven turbulence show good agreement with this experiment and provide insight into the source of the ion wave fluctuations.

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

[1] P.E. Young, Phys. Fluids B **5**, 2265 (1993).

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