17th ANOMALOUS ABSORPTION CONFERENCE

GRANLIBAKKEN CONFERENCE CENTER

TAHOE CITY, CALIFORNIA

MAY 17 - 22, 1987

Hosted By:

Lawrence Livermore National Laboratory
University of California

Conference Chairman: R. Paul Drake
Conference Coordinator: Sandy Auguadro

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AGENDA
17th ANOMALOUS ABSORPTION CONFERENCE
TAHOE CITY, CA -- MAY 17-22, 1987

Sunday:	6:00-8:00PM	Buffet Dinner
	8:00-10:00PM	Registration and Reception

Meals served as follows:

Breakfast	7:30-8:30 AM
Lunch	12:30-1:30 PM
Dinner	6:30-7:30 PM

	Category	Chairman
Monday:		
8:45 AM	Opening Remarks	R. P. Drake (LLNL)
A 9:00 AM Oral	Parametric Instabilities	R. W. Short (LLE)
B 7:30 PM Review	Studies of Laser Plasma Interactions Using Thomson Scattering H. A. Baldis (NRC)	C. Joshi (UCLA)
C 8:30 PM Poster	All Topics	
Tuesday:		
D 9:00 AM Oral	Implosions, Hydrodynamics	R. R. Johnson (KMS Fusion)

Tuesday:

E	7:30 PM	Review	Application of Ray-Tracing Techniques to Laser-Plasma Simulations R. S. Craxton (LLE)	W. C. Mead (LANL)
F	8:30 PM	Poster	All Topics	

Wednesday:

G	9:00 AM	Oral	Raman Scattering	D. Pesme (Ecole Poly)
H	7:30 PM	Review	Progress in the Linear Theory of Parametric Instabilities E. A. Williams (LLNL)	R. L. Berger (KMS)
I	8:30 PM	Poster	All Topics	

Thursday:

J	9:00 AM	Oral	Nonlinear Interactions	W. Rozmus (Univ. of Alberta)
K	7:30 PM	Review	The Role of Nonlinear Effects in RF Heating and Current Drive in Magnetic Fusion	W. L. Kruer (LLNL)
	9:00 PM		**Business Meeting**	

Friday:

L	9:00 AM	Oral	X-Rays: Conversion, Lasers	J. A. Cobble (LANL)

Monday 8:45 AM

8:45 Opening Remarks R.P. Drake (LLNL)

A **Parametric Instabilities (Oral)** R.W. Short (LLE)

9:00 A1 **Interaction Studies in a Long Homogeneous Plasma**, F. Amiranoff, C. Labaune, C. Rousseaux, B. Mabille, P. Mora, D. Pesme (Ecole Polytechnique Palaiseau), G. Mattieussent (Lab. de Phys. des Gas et des Plasmas-Orsay), D. Casanova (CEL-V), and H. Baldis (NRC)

9:15 A2 **High Energy Electrons in Laser Target Interactions**, F. Amiranoff, C. Labaune, C. Rousseaux, B. Mabille (Ecole Polytechnique-Palaiseau), and G. Matthieussent (Lab. de Phys. des Gas et des Plasmas-Orsay)

9:30 A3 **Study of Energetic Electron Emissions from Hot Underdense Plasmas**, S. Aithal, P. Lavigne, H. Pepin, T. W.Johnston (INRS-Energie), and K. Estabrook (LLNL)

9:45 A4 **Parametric Amplification: The Scattering Matrix and its Resonances**, T. W. Johnston (INRS-Energie)

10:00 A5 **Parametric Instabilities Driven by an Induced-Spatially-Incoherent Laser Beam**, R. L. Berger (KMS Fusion)

10:15 Coffee Break

10:45 A6 **Three Dimensional Calculations of ISI Filamentation**, Andrew J. Schmitt (NRL)

11:00 A7 **Lateral Thermal Transport Smoothing of Laser Intensity Nonuniformities in 0.53 μm Laser Irradiated Disk Targets**, C. L. Shepard, G. E. Busch, E. F. Gabl, B. H. Failor, and R. J. Schroeder (KMS Fusion)

Monday: AM

11:15 A8 **Synopsis of Results on Self Focusing and Filamentation in High Z Plasmas**, R. D. Jones, W. C. Mead, C. H. Aldrich, S. V. Coggeshall, J. L. Norton, G. D. Pollak, and J. M. Wallace (LANL)

11:30 A9 **Effects of Radiation, Convection, and Magnetic Fields on Self-Focusing in Large, High-Z, Short-Wavelength Laser-Produced Plasmas**, W. C. Mead, R. D. Jones, S. V. Coggeshall, J. L. Norton, and J. M. Wallace (LANL)

11:45 A10 **Interaction of a Nonuniform Laser Beam with an Underdense Plasma**, S. V. Coggeshall, W. C. Mead, R. D. Jones (LANL)

Monday 7:30 PM

B **Review and Discussion** Chairman: C. Joshi (UCLA)

Studies of Laser Plasma Interactions Using Thomson Scattering - H. A. Baldis (NRC)

Monday: 8:30 PM

C **All Topics (Poster)**

C1 **Self-Similar Cooling of Ablative Heat Waves by Non-Linear Heat Diffusion**, R. Pakula (Lehigh Univ.)

C2 **Radiative Preheat and its Effect on Shockwave Experiments in High-Z Targets**, A. Ng, P. Celliers, and D. Parfeniuk (Univ. B.C.)

Monday: PM

C3 **Spectroscopic Study of Single and Double Ni Foils for X-ray Laser Studies**, P. Audebert, T. Boehly, D. Bradley (LBL), R. S. Craxton, R. Epstein, M. C. Richardson, D. Shvarts (NRC-Negev), and B. Yaakobi (LLE)

C4 **Phebus: Absorption and X-ray Conversion Efficiency at 0.53 μm**, D. Juraszek (CEL-V)

C5 **Electron Heat Transport in a Microwave Driven Plasma** J. H. Rogers and J. S. DeGroot (UC-Davis)

C6 **Quasi-Resonant Decay of Ion Waves**, William L. Kruer (LLNL)

C7 **Simulation of Thermal and Pondermotive Self-Focusing in Long-Scale-Length Coronas**, D. Havazelet (NRC-Negev) D. Shvarts (NRC-Negev), and S. Skupsky (LLE)

C8 **Pulsation of ω and 2 ω Emission from Nd Laser-Produced Plasmas**, R. Dragila, B. Luther-Davies, A. Maddever (Australian National Univ.)

C9 **Dynamics of Large-Scale Cavitons in the Ionosphere,** J. P. Sheerin (KMS Fusion), L. M. Duncan and P. A. Bernhardt (LANL)

C10 **Competition Between Raman and Brillouin Scattering** Kent Estabrook and W. L. Kruer (LLNL)

C11 **Competition Between Raman and Brillouin Instabilities** M. Casanova (CEL-V), and D. Pesme (Centre de Phys. Theorique)

C12 **Application of Laser Fusion Tools to the Study of Laser Ablation and Fragmentation of Biological Calculi,** S. J. Gitomer and R. D. Jones (LANL)

Tuesday 9:00 AM

D Implosions, Hydrodynamics (Oral)

Chairman: R. R. Johnson (KMS Fusion)

9:00 D1 **Uniformity of Direct-Drive Laser Illumination Measured by X-ray Imaging**, F. J. Marshall, P. A. Jaanimagi, M. C. Richardson, C. Rapp, S. Morse, R. Hutchison, S. Noyes, T. Kessler, and W. Seka (LLE)

9:15 D2 **Effects of Illumination Non-Uniformities on the Interpretation of Streak Imaging of GlassMicroballoon Implosions**, J. Delettrez, G. Gregory, P. Jaanimagi, T. Kessler, M. C. Richardson, and S. Skupsky (LLE)

9:30 D3 **Time-Resolved Spectroscopy of Laser-Driven Spherical Targets**, D. K. Bradley (LBL), P. Audebert, J. Delettrez, R. Epstein, G. Gregory, B. L. Henke (LBL), P. A. Jaanimagi, M. C. Richardson, and B. Yaakobi (LLE)

9:45 D4 **Time-Resolved X-ray Diagnosis of the Acceleration Phase of ICF Implosions**, P. A. Jaanimagi, G. G. Gregory, D. K. Bradley (LBL), J. Delettrez, F. J. Marshall, P. W. McKenty, M. C. Richardson, and C. P. Verdon (LLE)

10:00 D5 **High Density Direct-Drive Gas Filled Target Implosions,** M. C. Richardson, P. Audebert, D. Bradley (LBL), J. Delettrez, G. G. Gregory, P. A. Jaanimagi, R. Keck, R. Kremens, F. J. Marshall, R. L. McCrory, P. W. McKenty, J. M. Sources and C. P. Verdon (LLE)

10:15 Coffee Break

10:45 D6 **Effect of Mixing on Interpretation of Reaction Product Measurement of ρR**, L. M. Goldman (LLE)

11:00 D7 **High Speed Detection of Thermonuclear Neutrons with Solid State Detectors**, D. R. Kania, S. Lane, B. Jones, and C. Bennett (LLNL)

Tuesday: AM

11:15 D8 **New Approach to Diagnosis of Fuel-Pusher Mixing in Inertial Confinement Targets** H. Azechi, R. O. Stapf, N. Miyanaga, M. Yamanaka, S. Ido, K. Nishihara, Y. Kitagawa and C. Yamanaka (Osaka Univ.)

11:30 D9 **Nonlinear Mode Coupling of the Rayleigh-Taylor Instability in Laser Ablatively Accelerated Targets** M. H. Emery and J. H. Gardner (NRL)

11:45 D10 **Rayleigh-Taylor Instability Growth Rates in Targets Accelerated by an ISI-Smoothed Laser Beam**,J. Grun, M. H. Emery, C. K. Manka, T. Y. Lee, E. A. McLean, A. Mostovych, J. Stamper, S. Bodner, S. P. Obenschain, B. H. Ripin (NRL)

12:00 D11 **Evidence of Rayleigh-Taylor Instabilities in Tri-Layer Experiments**, P. Holstein, B. Meyer, M. Rostaing, J. Bruneau, N. Wilke, D. Galmiche, and J. P. Nicolle (CEA-V)

12:15 D12 **Pressure Preheat and Planarity of Nova direct drive Experiments,** J. D. Kilkenny, D. W. Phillion, D. Munro, P. Young, and R. P. Drake, (LLNL)

Tuesday 7:30 PM

E **Review and Discussion** Chairman: W. C. Mead (LANL)

Application of Ray-Tracing Techniques to Laser-Plasma Simulations - R. S. Craxton (LLE)

Tuesday 8:30 PM

F **All Topics (Poster)**

F1 **Gamma Ray Production in CO_2 Laser-Plasma Irradiation**, G. D. Enright, N. K. Sherman, and N. H. Burnett (NRC)

Tuesday: 8:30 PM

F2 **Holographic Polarimetry**, C. C. Gomez (LANL)

F3 **Superathermal Electron Production in a Magnetized Plasma**, C. Domier and N. C. Luhmann, Jr. (UCLA)

F4 **Energy Absorption of Subpicosecond Very Intense Laser Pulses**, F. Brunel (NRC - Canada)

F5 **Alternative Analysis of CO_2 Laser-Produced Plasma Waves**, A. Simon, R. W. Short, W. Seka, and L. M. Goldman (LLE)

F6 **Gradient Stabilization of Ion-Electron Streaming Instabilities in Heavy Ion Fusion**, D. Hewett and W. Kruer (LLNL)

F7 **Numerical Studies of Ultra-Strong Langmuir Turbulance**, J. P. Sheerin (KMS Fusion)

F8 **Kinetic Effects in the Evolution of Localized Langmuir Waves**, W. Rozmus, J. C. Samson and R. Teshima (Univ. of Alberta)

F9 **Competition Between Forward Raman and Backward Brillouin Instabilities**, M. Casanova (CEL-V) and D. Pesme (Ecole Polytechnique-Palaiseau)

F10 **Role of Langmuir Wave Non-Linearities in Stimulated Raman Scattering (S.R.S.)**, G. Bonnaud (CEL-V) and D. Pesme (Ecole Polytechnique-Palaiseau)

Wednesday 9:00 AM

G **Raman Scattering (Oral)** Chairman: D. Pesme (Ecole Poly)

9:00 G1 **Raman Emission with ISI**, S. P. Obenschain, K. J. Kearney, C. K. Manka, A. N. Mostovych, C. J. Pawley, J. Grun and J. A. Stamper (NRL) and D. R. Kania (LLNL)

Wednesday AM

9:15 G2 **Beyond the Zakharov Model-The Collapse of SRS Excited Langmuir Waves Initiated by Their Nonlinear Steepening**, B. Bezzerides, C. H. Aldrich, D. F. DuBois, H. A. Rose (LANL)

9:30 G3 **Transition Regime in the Coupling of SRS and SBS in Slab Geometry**, H. A. Rose, D. F. DuBois, and B. Bezzerides (LANL)

9:45 G4 **Growth and Collapse of Langmuir Waves from Stimulated Raman Scattering** D. M. Villeneuve, H. A. Baldis and J. E. Bernard (NRC)

10:00 G5 **Observation of Steepening in Electron Plasma Waves Driven by Stimulated Raman Backscattering**, D. Umstadter, R. Williams, C. Clayton, and C. Joshi (UCLA)

10:15 Coffee Break

10:45 G6 **Absolute Stimulated Raman Backscatter at High Laser Intensities**, R. W. Short and A. Simon (LLE)

11:00 G7 **Nonlinear Theory of Absolute Raman Instability at the Quarter Critical Density**, P. Guzdar, Y. C. Lee, and Chuan Sheng Liu (Univ. of Maryland)

11:15 G8 **Stimulated Raman Scattering in the Presence of Long Wavelength Density Fluctuations**, B. B. Afeyan, J. F. Drake, Y. C. Lee, and C. S. Liu (Univ. of Maryland)

11:30 G9 **Enhanced Thomson Scattering in Underdense Targets**, A. Simon and R. W. Short (LLE)

11:45 G10 **Observations of Enhanced Thomson Scattering**, S. H. Batha, L. M. Goldman, W. Seka, and A. Simon (LLE)

Wednesday 7:30 PM

H **Review and Discussion** Chairman: R. L. Berger (KMS)

Progress in the Linear Theory of Parametric Instabilities, E. A. Williams (LLNL)

Wednesday 8:30 PM

I **All Topics (Poster)**

I1 **Photoresonant Absorption and Line Spectra for Neon Plasmas**, R. A. Walton, P. Filbert, J. Hawley, D. Kohler, and J. D. Perez (Lockheed)

I2 **Analysis of Dot Spectroscopy Experiments** M. D. Rosen, B. K. Young, and R. E. Stewart (LLNL), G. Charatis, and G. E. Busch (KMS Fusion)

I3 **Rear Side Heating of Laser Irradiated Thin Foils**, R. Benattar and J. Godart (Ecole Poly.)

I4 **Evolution of Laser Filaments in Fusion Plasmas**, R. Rankin, R. Marchand, and C. E. Capjack (Univ. of Alberta)

I5 **Effects of Induced Spatial Incoherence on Raman Scattering**, A. Bourdier (CEA de Vaujours) and E. A. Williams (LLNL)

I6 **Measurements of SBS Spectra With ISI Illumination**, A. N. Mostovych, C. K. Manka, S. P. Obenschain, C. J. Pawley, J. Grun, and K. J. Kearney (NRL)

I7 **SBS Spectra from Double-Foil Targets**, L. V. Powers and R. L. Berger (KMS Fusion)

Wednesday 8:30 PM

I8 **Spatio-Temporal Energy Cascading in the Beat-Wave Accelerator**, C. J. McKinstre, D. W. Forslund (LANL) and S. H. Batha (LLE)

I9 **Plasma Wave Wigglers for Free Electron Lasers**, C. Joshi, T. Katsouleas, J. M. Dawson, W. B. Mori, and Y. T. Yan (UCLA)

I10 **CO_2 Laser-REB Interaction "S Program"**, Y. Kitagawa, K. Mima, H. Fujita, H. Nakajima, H. Takabe, K. Nishihara, H. Azechi, K. Tanaka, C. Yamanaka (Osaka Univ.), and N. Ohigashi (Kansai Univ.)

Thursday 9:00 AM

J Nonlinear Interactions

Chairman: W. Rozmus (Univ. of Alberta)

9:00 J1 **Reflectivity from SBS for a Broadband Incident Light**, A. Lesne, G. Laval, and D. Pesme (Ecole Polytechnique Palaiseau), M. Casanova (CEL-V)

9:15 J2 **Observations of Scattered Fundamental Light From Exploding Foil Plasmas**, P. E. Young, R. P. Drake, D. L. Montgomery, R. E. Turner, D. W. Phillion, E. A. Williams, B. F. Lasinski, Kent Estabrook, and W. L. Kruer (LLNL)

9:30 J3 **Stimulated Brillouin Scattering from KrF Laser-Produced Plasma**, R. Fedosejevs, J. Santiago, P. D. Gupta, R. Popil, and A. A. Offenberger (Univ. of Alberta)

9:45 J4 **Modulation Instability in the Beat Wave Experiments**, D. Pesme (Ecole Polytechnique-Palaiseau), S. Karttunen (Tech. Research Centre of Finland), G. Laval, N. Sylvestre, and R. Salomaa (Helsinki Univ. of Tech.)

Thursday: AM

10:00 J5 **Pic-Code Studies of Beat Wave Saturation**, G. Bonnaud (CEA-V), D. Pesme (Ecole Poly.), J. P. Matte (INRS-Energie)

10:15 Coffee Break

10:45 J6 **Absorption in Short Pulse Nd Laser-Produced Plasmas**, R. Dragila, B. Luther-Davies, A. Perry (Australian National Univ.)

11:00 J7 **Absorption of fs Laser Pulses in Solid Targets and Plasma Formation**, P. Mulser (Technische Hochschule Darmstadt)

11:15 J8 **Laser Induced Anisotropies in Ion Acoustic Waves**, J. E. Bernard, H. A. Baldis, D. M. Villeneuve (NRC), and A. B. Langdon (LLNL)

11:30 J9 **Consequences of Deformed Electron Velocity Distributions in the Corona**, Jean-Pierre Matte (INRS-Energie), J. F. Luciani, M. Bendib (Ecole Polytechnique-Palaiseau), and T. W. Johnston (INRS-Energie)

11:45 J10 **Target Charging in Evacuated Target Chambers**, A. Bruce Langdon (LLNL)

12:00 J11 **Measurements of Anomalous Thermal Electron Heating and Heat Transport**, K. Mizuno and J. S. DeGroot (UC-Davis)

Thursday 7:30 PM

K **Review and Discussion** Chairman: W. L. Kruer (LLNL)

The Role of Nonlinear Effects in RF Heating and Current Drive in Magnetic Fusion, M. Porkolab (MIT)

Thursday 9:00 PM

Business Meeting Chairman: R.P. Drake(LLNL)

8:30

Friday ~~9:00~~ **AM**

L X-Rays: Conversion, Lasers (Oral)

Chairman: J. A. Cobble (LANL)

GO TO C1

9:00 L1 **Effects of ISI on the Interaction of 1.05μm Light with High-Z Plasmas**, D. R. Kania and P. Bell (LLNL)

9:~~15~~ 00 L2 **Advances in Time-Resolved Measurements of X-ray Conversion Efficiencies,** F. Ze, H. Kornblum, B. Lasinski, R. Thiessen, R. Kauffman, R. P. Drake, S. Langer, D. Montgomery, L. Sutter, and G. Tietbohl (LLNL)

9:~~30~~ 15 L3 **Gold Disc Irradiations at 3 ω ,** B. F. Lasinski, F. Ze, R. L. Kauffman, A. R. Thiessen, H. N. Kornblum, and R. P. Drake (LLNL)

9:~~45~~ 30 L4 **Experiments with Laser Heated Cavities**, G. S. Tsakiris, R. Sigel, K. Eidmann, I. B. Folders, P. Herrmann, R. Pakula, S. Sakabe, S. Witkowski (Max-Planck-Institut fur Quantenoptik)

~~10:00~~ 9:45 L5 **Design and Optimization of Recombination X-Ray Lasers**, R. Epstein (LLE), D. Shvarts (NRC-Negev), S. Skupsky, and B. Yaakobi (LLE)

10:15 Coffee Break

10:~~45~~ :00 L6 **Beam Optics of Laboratory X-ray Lasers**, Richard A. London (LLNL)

~~11:00~~ 10:15 L7 **Studies of High Density Plasma Waveguides for X-ray Lasers**, D. Shvarts, M. C. Richardson, B. Yaakobi, P. Audebert, T. Boehly, D. Bradley (LBL), R. S. Craxton, R. Epstein, R. L. McCrory, and J. M. Soures (LLE)

Friday **AM**

10:30
~~11:15~~L8 **Experimental Study of Single and Double Foils for X-ray Laser Media**, T. Boehly, P. Audebert, D. Bradley (LBL), R. S. Craxton, R. Epstein, M. C. Richardson, D. Shvarts (NRC-Negev), and B. Yaakobi (LLE)

10:45
~~11:30~~L9 **Energy Partitioning of Irradiated Targets**, J. P. Knauer, O. B~~o~~arnouin, R. Keck, J. Delettrez, and S. Letzring (LLE)

Session A

(Oral)

Parametric Instabilities
and
Filamentation

Monday, 9:00 AM

Chairman: R. W. Short (LLE)

A1

Interaction Studies in a Long Homogeneous Plasma

F. Amiranoff, C. Labaune, C. Rousseaux
B. Mabille, P. Mora, D. Pesme (Ecole Polytechnique-Palaiseau),
G. Mattieussent (Laboratoire de Physique des Gas et des Plasmas-Orsay)
M. Casanova (CEL-V) and H. Baldis (NRC)

Interaction mechanisms between a high intensity laser beam and a long homogenous underdense plasma are studied both in the contexts of laser fusion and new particle accelerator concepts.

The plasma is created by irradiation of a thin foil by a first laser beam ($\lambda - 0.53$ μm, $\tau = 600$ ps, $I = 10^{13}$ W/cm^2). After an adjustable time delay (400 ps - 2.5 ns), the main beam ($\lambda = 0.26$ μm, $\tau = 400$ ps, $I = 3.10^{14}$ W/cm^2) interacts with the performed plasma about 1 mm long.

Results on transmission, Brillouin scattering, forward and backward Raman scattering are presented. Applications in the two physical contexts are discussed.

A2

Go to
I 11

High Energy Electrons in Laser Target Interactions

F. Amiranoff, C. Labaune, C. Rousseaux
B. Mabille (Ecole Polytechnique-Palaiseau), and G. Matthieussent
(Laboratoire de Physique des Gas et des Plasma-ORSAY)

The angular distribution of high energy electrons emitted during laser-matter interactions is measured. Experiments are performed on plastic foils 3000 Å to 100 µm thick. The Nd glass laser of the GRECO. LM is used either at $\lambda = 1.05$ µm ($\tau = 600$ ps, $I = 2.10^{15}$ W/cm^2) or at $\lambda = 0.26$ µm ($\tau = 400$ ps, $I = 1.10^{15}$ W/cm^2). The electron spectra up to 300 keV are measured with a magnetic electron spectrometer at several angles from the target normal.

The different possible generation mechanisms for the high energy electrons are discussed.

A3

Study of Energetic Electron Emissions
From t Underdense Plasmas

S. Aithal, P. Lavigne, H. Pepin,
T. W. Johnston (INRS-Energie) and K. Estabrook (LLNL)

The latest results of the ongoing study of energetic electron emission and light scattering performed in case of an underdense ($\leq$ n_c/ , (~ 15 keV) plasma using a 10.6 μm CO_2 at intensities up to 2.5 x 10^{14} cm^2 in thin exploding foils will be presented. The Raman process manifesting itself at or near the quarter critical density region has been found to be responsible for the generation of the hot (T_h ~ 150 keV) tail of energetic electrons up to 1 MeV. This experimental result is consistent with the results of a 1½ dimensional particle-in-cell code simulation with a parabolic density profile, resembling the experiments. There is experimental evidence that the most energetic electrons, those of energy above 1 MeV, are generated by forward Raman process taking place at lower density ($<$ 0.1 n_c). The results will be presented of an experiment to correlate these very high energy electrons (up to 2.3 MeV) with forward scattered light whose wavelength is close to that of the pump.

Parametric Amplification: The Scattering Matrix and its Resonances

Tudor Wyatt Johnston (INRS-Energie)

Absolute instabilities and their point-spectrum growth rates are well understood for coupled-mode parametric instabilities in media which are 1-D nonuniform when none of the waves are close to their turning points. However, the continuum-frequency amplifying behaviour, which must give infinite amplification at the appropriate point frequency as absolute instability is approached, is less well understood, except for the specially simple case of the Rosenbluth amplifier.[1] The approach to threshold from below is here explored from the point of view of the wave scattering matrix and its complex-frequency resonances.

1. TW. Johnston and E.A. Williams, Bull. Am. Phys. Soc. 31(9), 1567 (1986), abstract 7R3

A5

Parametric Instabilities Driven by an Induced-Spatially-Incoherent Laser Beam

R. L. Berger (KMS Fusion, Inc.)

The growth rate of parametric instabilities is obtained for an incoherent laser beam by solving coupled mode equations. A spatially-incoherent laser beam is modeled as the sum of beamlets with randomly chosen phases and slightly different propagation directions. The phases of the individual beamlets change independently and discontinuously at randomly distributed times (a Kubo-Anderson process). Two competing effects are evident: 1) daughter waves can not be in phase with all beamlets everywhere and 2) the interference pattern leads to regions of high and low intensity. The first effect acts to reduce the growth rate; the second, to enhance the growth rate. For small bandwidth, the second effect is more important; whereas, the first (dephasing) effect is more important for large bandwidth. Increasingly, the bandwidth necessary to reduce the growth rate is much less than that required for an equivalent single laser beam.

at random

Three-Dimensional Calculations of ISI Filamentation

A. J. Schmitt (NRL)

Induced Spatial Incoherence (ISI) can provide a very smooth time-averaged illumination profile[1], and has been experimentally shown to suppress evidence of plasma instabilities[2]. Previous two dimensional calculations[3] have found that ISI suppresses filamentation (thus presumably lowering instability levels). In addition the time averaged illumination profile is relatively smooth even in the high coupling regime where filaments form and decay on rapid time scales. Analysis predicts that the filamentation behavior should be the same, to first order, for two- or three-dimensional filamentation. However, the actual three dimensional situation may be less favorable for ISI. Three dimensional filaments, if they form, can focus to a much higher peak intensity than in two dimensions. This effect would be more pronounced in ~~the highly coupled regime,~~ which has been accessed in recent experiments with the Pharos III laser at 1.06 μm. We have performed time-dependent three-dimensional simulations of the ISI laser-plasma interaction behavior in this regime. Comparisons with experiment and the previous 2-D calculations will be presented.

*Supported by Department of Energy

1. R.H. Lehmberg and S.P. Obenschain, Opt. Commun. 46, 27 (1983).

of laser propagation

2. S.P. Obenschain, et. al., Phys. Rev. Lett. 56, 2807 (1986.)
3. A.J. Schmitt, Bull Am. Phys. Soc. 31, 1408 (1986).

Lateral Thermal Transport Smoothing of Laser Intensity Non-uniformities in 0.53 μm Laser Irradiated Disk Targets

Chet
C. L. Shepard, G. E. Busch, E. F. Gabl,

B. H. Failor, and R. J. Schroeder (KMS Fusion) (strong precursor

sho breakout)

Efficient smoothing of laser intensity nonuniformities will help reduce driver uniformity requirements for direct drive ICF. However, it is believed that the degree of smoothing diminishes with decreasing laser wavelength. Measurements of thermal smoothing are therefore of interest.

We have measured thermal smoothing of laser nonuniformities by imposing a known high intensity perturbation on a fairly uniform beam and observing the shock wave as it traverses the irradiated target. Since the shock pressure is related to the ablation pressure, streak records of the shock breakout yield the magnitude as well as the spatial variation of the ablation pressure, and thus the amount of thermal smoothing can be determined. For the experiments temporally flat pulses of 1 ns duration were used. The laser intensity was ~1 x 10^{14} W/cm^2 with $\lambda = 0.53$ μm, and the targets were Si disks. Results will be presented.

A8

Synopsis of Results on Self-Focusing and Filamentation in High-Z Plasmas

Paper at ECLIM

R. D. Jones, W. C. Mead, C. H. Aldrich, S. V. Coggeshall,
J. L. Norton, G. D. Pollak, and J. M. Wallace (LANL)

We present an overview of recent theoretical results on self focusing and filamentation in high Z plasmas.[1] Earlier work[2] is confirmed and extended.

(1) LASNEX modeling of self focusing behavior is very dependent on the heat flux model for early times. At late times, however, the behavior approaches a common steady state. Preliminary VENUS modeling suggests the heat flux is near classical.

(2) In high Z, low density plasmas, collisional absorption and self focusing are strongly competing processes. Under many conditions of interest, no intensity amplification ocurrs at focus. The intensity at focus is rarely amplified more than a few times above its incident value.

(3) In agreement with earlier results,[3] diverging optics decreases self focusing behavior.

(4) Laser beams in large scale mass density gradients in plasmas near pressure balance demonstrate behavior similar to beams in homogeneous plasmas.

(5) Large scale background beams with intensities less than 10% of the main beam intensity had little effect on self focusing. On the other hand, smaller scale hot spots with intensities greater than 10% had a significant effect.

(6) Very small scale hot spots with radii on the order of an electron mean free path tend to "flicker". The motion seems to be mediated by sound waves.

(7) When the radiation physics is included, small scale structures are generated even when small scale seeds are not explicitly initiated. This effect seems to ~~be related to~~ the radiational cooling instability. Includes non-LTE

(8) Collisional absorption and Landau damping are both important in determining SRS backscatter levels. High Z plasmas and short wavelengths decrease SRS levels. For many cases of interest, SRS levels are likely to be quite low.

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[1] R. D. Jones, W. C. Mead, C. H. Aldrich, S. V. Coggeshall, J. L. Norton, G. D. Pollak, and J. M. Wallace, Phys. Fluids , submitted.

[2] K. Estabrook, W. L. Kruer, and D. S. Bailey, Phys. Fluids **28** 19 (1985); R. S. Craxton and R. L. McCrory, J. Appl. Phys. **56** 108 (1984).

[3] A. B. Langdon, 13th Anomalous Absorption Conference, (1983).

A9

Effects of Radiation, Convection, and Magnetic Fields on Self-Focusing in Large, High-Z, Short-Wavelength Laser-Produced Plamsas

W. C. Mead, R. D. Jones, S. V. Coggeshall, E. L. LINDMAN
J. L. Norton, and J. M. Wallace (LANL)

Thermal self-focusing can be important in short-wavelength laser-produced plasmas.[1] We have used LASNEX and VENUS simulations to study the behavior of thermal self-focusing and filamentation in large 0.25 μm laser-produced gold plasmas. Here, we concentrate on the particular effects of radiation, convection, and magnetic fields.

Non-LTE radiation processes lead to the generation of sub-beam focusing structures.[2] We discuss the scale-sizes, energetics, and mechanisms of the formation of these structures.

We examine the effects of plasma convection on self-focusing. We simulate the evolution of a laser-produced corona, with realistic expansion densities, velocities, and scalelengths. The effects of plasma evolution on self-focusing are discussed.

Previously, we studied the development of magnetic fields using VENUS calculations based on plasma and heating conditions determined from LASNEX calculations. The VENUS simulations predict modest field strengths and negligible effects of the fields on electron transport. We discuss here issues of self-consistency and present LASNEX calculations including magnetic field generation in a Braginskii formulation.

[1] M.J.Herbst, *et al.*, Phys. Rev. Lett. *46*, 328 (1981); R.S.Craxton and R.L.McCrory, J. Appl. Phys. *56*, 108 (1984); K.G.Estabrook, W.L.Kruer, and D.S.Bailey, Phys. Fl. *28*, 19 (1985).

[2] R.G.Evans, J. Phys. D *14*, L173 (1981).

•Work supported by U.S.D.O.E.

Interaction of a Non-uniform Laser Beam with an Underdense Plasma

S. V. Coggeshall, W. C. Mead, and R. D. Jones (LANL)

Recently[1] we presented 2-D LASNEX calculations of the interaction of a "dirty" laser beam with a confined underdense gold plasma. The beam is characterized by a uniform background with an applied small-scale-length ($\lambda_\perp \simeq 80\mu m$) spatial structure and a peak-to-average value of ~ 2. We showed a focusing phenomenon different from normal filamentation which never achieves a steady state behavior. The focal spots shift throughout the plasma and significant intensity multiplication occurs. The present calculations extend our previous model by including hydrodynamic expansion and radiation physics. We discuss the conditions for the occurance of this "flicker" phenomenon and the effects of these more realistic conditions.

[1] S. V. Coggeshall *et al.*, Bull. Amer. Phys. Soc. <u>30</u>, 1585 (1986).

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

Session B

(Review)

Studies of Laser-Plasma Interactions Using Thomson Scattering

H. A. Baldis (NRC)

Monday, 7:30 PM

Chairman: W. C. Mead (LANL)

Studies of Laser-Plasma Interactions Using Thomson Scattering

Hector A. Baldis, (NRC-Canada)

Thomson scattering has been extensively used during the past few years to study laser-plasma interactions in different laboratories. Since the diagnostic permits us to measure directly the enhanced level of fluctuations in the plasma, it has allowed detailed studies of parametric instabilities and other wave phenomena in the plasma corona. Althouth not limited to long-wavelength-laser plasma, most studies have been done with 10.6 μm-laser-plasmas where a shorter wavelength probe is easily obtained.

We will review novel techniques used in Thomson scattering in laser produced plasmas, as well as experiments that clearly demonstrate its usefulness and elegance.

Session C

(Poster)

All Topics

Monday, 8:30 PM

Self-Similar Cooling of Ablative Heat Waves by Non-Linear Heat Diffusion

R. Pakula (Lehigh University)

The problem of cooling of ablated heated matter by a process of non-linear heat diffusion admits self-similar solutions which are approached asymptotically as the matter expands and its mean density decreases far below the solid state density. Like in the case of heating, the rate of cooling can be characterized by a related time dependence in the plasma temperature at the boundary with the vacuum. In contrast with the cases of heating treated previously in the literature, it is shown that for the present cooling process, dimensional analysis is not always a useful tool for the solution of the problem. For example, the ablative heat wave with a constant energy content corresponds to the so called self-similar solutions of the second type, where the cooling rate can be found only by trial and error in the numerical integration of the hydrodynamic differential equations including non-linear heat diffusion. Numerical examples are given for the cooling of gold plasmas by non-linear heat diffusion accomplished by line and inverse brehmsstrahlung-emission.

Radiative Preheat and its Effect on Shockwave Experiments in High-Z Targets

A. Ng, P. Celliers, and D. Parfeniuk
(Univ. of British Columbia)

The rear surface temperatures of relatively thick, high-z targets (20 µm and 15 µm molydenum) irradiated with 0.53 µm laser light were determined from temporally resolved measurements of the rear surface luminous emission spectra. In contrary to low-z targets such as magnesium and aluminum, radiative preheat was observed to dominate over shock heating even at modest irradiance of 10^{13} W/cm^2. This poses great difficulties in the study of laser-driven shock waves in high-z targets from observations of shock breakout at the target rear surface. Furthermore, the result suggests that shock formation was affected by the preheat.

Spectroscopic Study of Single and Double Ni Foils for X-ray Laser Studies

P. Audebert, T. Boehly, D. Bradley (LBL),
R. S. Craxton, R. Epstein, M. C. Richardson (LLE),
D. Shvarts (NRC-Negev), and B. Yaakobi (LLE)

We analyze the spectra from Ni targets and assess the behavior of several types of planar targets. We present spatially resolved x-ray spectra from a KAP crystal spectrograph in the 0.6-1.5 keV range and XUV spectra from a 1-m grazing incidence spectrograph in the 40-250 eV range for various planar Ni targets irradiated with 10^{13}-10^{14} W/cm^2 of 527-nm laser light in a line focus. We study thin (300-800 Å) exploding Ni foils and double Ni foils (which may employ exploding thin foils, massive targets or both) separated by 150-300 μm. We identify the spectral lines and unresolved transition arrays using a relativistic atomic structure code. We estimate the relative populations of the various ionization states in the Ni plasma, as well as the temperature and density profiles, for the various target configurations. In terms of possible x-ray-laser geometries these results demonstrate that the multiple-foil configurations generate plasmas of greater extent and higher density than single exploding foils. These experiments are simulated using hydrodynamic computer codes.

a) Lawrence Berkeley Laboratory, Berkeley California

b) Visiting scientist on leave from Nuclear Research Center Negev, Israel

"This work was supported by the Naval Research Laboratory under contract No. 0014-86-C-2281 and by the Sponsors of the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics."

Phebus: Absorption and X-ray Conversion Efficiency at 0.53μm

D. Juraszek (CEL-V)

Electron Heat Transport in a Microwave Driven Plasma

J. H. Rogers and J. S. DeGroot (UC-Davis)

Temporal and spatial measurements of electron heat transport are performed in the U.C.D. Aurora device. In this device, microwaves heat a region of underdense plasma ($n/n_c \lesssim 1$) in which the ion acoustic decay instability is strongly driven. In this region, strong electron thermal heating ($T_t < 1$ eV) as well as suprathermal heating ($T_h < 4$ eV) is observed. The transport of the absorbed energy into the adjacent collisional plasma ($T_e > 0.15$ eV, $n_e \lesssim 1.8 \times 10^{10}$ cm^{-3}, so $\lambda e \gtrsim 2$ cm) is measured using Langmuir probes. The Aurora device models some of the phenomena that are believed to be important in the transport of absorbed laser energy into the overdense plasma in a laser driven pellet.

*Work partially supported by Lawrence Livermore National Laboratory

Quasi-Resonant Decay of Ion Waves

William L. Kruer (LLNL)

Quasi-resonant decay of ion acoustic waves has been proposed[1] as a saturation mechanism for the Brillouin instability. This decay of a driven ion wave into lower wavenumber ion waves is examined in theory and in simulations using a two-fluid code. Our results emphasize the importance of including harmonic generation of the driven ion wave, which is also quasi-resonant and which can qualitatively affect the decay instability. Applications to laser plasma interactions are discussed.

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

[1] S. J. Karttunen, J. N. McMullin and A. A. Offenberger, Phys. Fluids 24, 447 (1981); and references therein.

Simulation of Thermal and Pondermotive Self-Focusing in Long-Scale-Length Coronas

D. Havazelet, D. Shvarts (NRC-Negev)
and
S. Skupsky (LLE)

We investigate the effect of both thermal and pondermotive self-focusing on laser propagation and plasma behavior in the corona. The simulations were done using a 2-D hydrodynamic code in which the laser propagation is modeled by solving the paraxial wave equation which includes the effects of refraction, diffraction, absorption and pondermotive forces.

Pulsation of ω and 2 ω Emission from Nd Laser-Produced Plasmas

R. Dragila, B. Luther-Davies,
A. Maddever (Australian National University)

Both ω and 2ω emission from plasmas generated by 60–400psec duration 1μm Nd laser radiation at intensities above $\approx 10^{14}$W/cm^2 has been found to pulsate with average burst lengths as short as 10psec. The emission is localised in small regions ≈5μm in diameter with their position and intensity varying randomly from shot to shot. The nature of the pulsations above threshold is little influenced by parameters such as the laser intensity or target material, however, the 2ω pulsations can be supressed if the focussing geometry of the heating pulse at the target surface is changed from diverging to converging by simply moving the target position from behind to in front of the laser focus (F=1 optics). The influence of these temporal modulations on the spectra of the emitted light and possible mechanisms leading to this behaviour will be discussed.

Dynamics of Large-Scale Cavitons in the Ionosphere

J. P. Sheerin (KMS Fusion), L. M. Duncan
and
P. A. Bernhardt (LANL)

In March 1985, Duncan and Sheerin discovered strong deformations (depletions of over 70%) of the ionospheric plasma profile, produced by intense RF heating (1-3). These depletions assume the form of large-scale cavities which exhibit true soliton-like behavior, including maintenance of individual identities in mutual interactions and their extreme longevity (hours), after the pump is turned off. Since those first experiments, several more have been performed to elucidate the morphology and dynamics of these cavities. Temporal and spatial scales observed strongly suggest nonlinear Ohmic heating as the main participant in the creation of the large-scale cavities. Processes involving the fission of large cavitons into several smaller ones and the fusion of several small cavitons into large cavitons have been observed. Strong ion-acoustic and Langmuir turbulence are shown to occur inside these cavities. On the shortest timescales of current experiments (6 second resolution), caviton dynamics are dominated by production processes and can be compared qualitatively to numerical simulations. The larger cavitons have been tracked for over 30 minutes, and their dynamics and drifting motion over these longer periods are more strongly influenced by the conditions of the ambient ionosphere. The recent addition of photometric measurements and CCD imaging of the enhanced airglow produced by suprathermal electron fluxes along with simultaneous radar measurements, have added greatly to our understanding of the dynamics of the heated region and its structuring. Results from these latest experiments will be summarized.

1. J. P. Sheerin, et al., 15th Annual Anomalous Absorption Conf., Banff, Alta., 1985.
2. J. P. Sheerin, 16th Annual Anomalous Absorption Conf., Lake Luzerne,N. Y., 1986.
3. L. M. Duncan, J. P. Sheerin, R. A. Behnke and P. A. Bernhardt, Phys. Rev. Lett. (submitted).

Competition Between Raman and Brillouin Scattering

Kent Estabrook and W. L. Kruer (LLNL)

Brillouin scattering can reduce both the level and heated electron temperatures of Raman scattering. Conversely, Raman heating can reduce Brillouin scattering[1]. Raman instability reduction with the onset of Brillouin scattering has been observed in experiment[2].

We present results of 1.5-D kinetic simulations of Raman scattering with and without Brillouin scattering. The intensity was 2.5×10^{15} W/cm^2, T_e=1 KeV, and the plasma length was $128\lambda_0$. At density n/n_c=0.2, Raman absorbs so vigorously that Brillouin makes little difference. At densities n/n_c=0.1 and 0.05, Brillouin scattering drops Raman backscattering by a factor of a few compared to fixed ion simulations and also considerably depletes Raman forward scattering.

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

1. K.Estabrook et al., Phys.Rev.Lett. **46**, 724(1981); K.Estabrook, W.L.Kruer and M.G.Haines, Report of workshop on interactions and transport in laser-plamas, Centre Europeen de Calcul Atomique et Moleculaire, Orsay, France, 1984.
2. C.J.Walsh, D.M.Villeneuve, and H.A.Baldis, Phys.Rev.Lett. 53, 1445 (1984).

Competition Between Raman and Brillouin Instabilities

M. Casanova (CEL-V)
and
D. Pesme (Ecole Polytechnique-Palaiseau)

The competition between Raman and Brillouin instabilities is investigated numerically by using a mode coupling code in which stimulated Raman scattering and stimulated Brillouin scattering are dealt with in the limit of the envelope approximation. The coupling of the plasma waves to the ion sound waves is also taken into account in the limit of the decay instability.

Application of Laser Fusion Tools to the Study of Laser Ablation and Fragmentation of Biological Calculi

S. J. Gitomer and R. D. Jones (LANL)

Laser ablation and fragmentation of renal and biliary stones in vitro and in vivo has been successfully demonstrated [1]. Laser light incident upon the stone appears to produce a plasma which generates a shock wave that propagates through the stone fracturing it. The elucidation of the physical mechanisms which are important in this laser-matter interaction is the subject of this research.

The LASNEX computer code was used in the modeling [2]. The code solves the coupled hydrodynamic and radiation transport equations in one or two dimensions and includes laser light absorption either via inverse bremsstrahlung or tabular absorption opacities. Equation of state tables from the Los Alamos Sesame Library were used for the materials of interest.

The experimental data using a nominal 1 microsecond pulsed 500 nm dye laser [1] provided the following against which to compare the calculations: (1) mass removal for a range of laser pulse energies; (2) timing of visible light emission relative to the laser pulse onset; (3) absorption and emission spectra of Ca lines and continuum during the laser pulse; and (4) efficiency of stone fragmentation for illumination in atmospheric or liquid environment. The results of the comparison of experiment and calculation will be presented.

The following physical picture emerges from the modeling. The laser light is almost completely absorbed in the plasma which it produces. The plasma electrons are heated and equilibrate with the plasma ions. This hot plasma produces a thermal wave which penetrates into the dense material and deposits its energy in depth as heat driving material ablation. It is the ablation and associated reaction force which in turn drives a shock further into the dense material causing fracturing. A non-negligible component in the energy balance is ultraviolet blackbody radiation at a temperature of 5 eV.

This work was performed under the auspices of the United States Department of Energy.

[1] R. R. Anderson, N. Nishioka, S. Dretler & J. Parrish, "Pulsed Laser Fracturing of Renal & Biliary Stones," CLEO 1986, paper TUP1, p. 136; P. Teng, N. S Nishioka, R. R. Anderson & T. F. Deutsch, "Optical Studies of Pulsed-laser Fragmentation of Biliary Calculi," Applied Physics (accepted for publication); P. Teng, N. S. Nishioka, R. R. Anderson & T. F. Deutsch, private communication.

[2] G. B. Zimmerman & W. L. Kruer, "Numerical Simulation of Laser Initiated Fusion," Comments on Plasma Physics & Controlled Fusion 2, 85 (1975); N. Delamater, M. A. Mahaffy, J. Norton, J. Saltzman & A. J. Scannapieco, (Los Alamos LASNEX Team) private communication.

Session D

(Oral)

Implosions and Hydrodynamics

Tuesday, 9:00 AM

Chairman: R. R. Johnson (KMS Fusion)

DX
2

Uniformity of Direct-Drive Laser Illumination Measured by X-ray Imaging

F. J. Marshall, P. A. Jaanimagi, M. C. Richardson, C. Rapp, S. Morse,
R. Hutchison, S. Noyes, T. Kessler, and W. Seka (LLE)

We have investigated the technique of estimating laser illumination uniformity by measurement of the distribution of x-ray emission resulting from laser illumination of gold coated spherical targets. Measurements of the equivalent target plane distribution of UV (351 nm) intensities from single beams of the University of Rochester Omega laser system were taken in conjunction with measurements of the spatial distribution of x-ray emission from simultaneously illuminated gold coated targets. These measurements demonstrate the spatial correspondence between variations in UV irradiation uniformity and x-ray emission uniformity. Strategies for enhancing direct drive target illumination uniformity investigated with this technique will be discussed.

"This work was supported by the U.S. Department of Energy Office Of Inertial Fusion under agreements No. DE-FC08-85DP40200 and by the Sponsors of the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics."

D~~2~~
5

Effects of Illumination Non-Uniformities on the Interpretation of Streak Imaging of Glass Microballoon Implosions

J. Delettrez, G. Gregory, P. Jaanimagi, T. Kessler,
M. C. Richardson, and S. Skupsky (LLE)

Streak imaging of the self-emission of imploding laser fusion targets has been used to measure the trajectory of the imploding shell and the implosion time.[1] Both the shell trajectory and the implosion time are sensitive to the mass-ablation rate and, therefore, to the thermal transport calculated in simulation codes. As a transport diagnostic, the bulk shell trajectory is better than x-ray burnthrough diagnostics because it is an integrated measurement that is not sensitive to the laser illumination non-uniformity. Also, the thickness and structure of the self-emission region is expected to yield information on shell characteristics during the implosion, such as its uniformity or its break-up due to instabilities. We report here results from the simulation of shell targets implosions carried out on the OMEGA laser system at 351 nm. The effect of laser illumination non-uniformity is taken into account using a model presented in a previous conference.[2] In this model, the 1D simulation code LILAC is run for all groups in a histogram of the laser intensity distribution on target and a weighted-average streak image is obtained by combining the images from each individual laser intensity weighted by the energy fraction in that intensity group. Thermal transport conclusions inferred from implosion time will be compared to conclusions based on laser absorption fraction and from past transport experiments. The effect of laser illumination non-uniformity on the thickness of the emitting region will be discussed; simulation results will be compared to experiment observations.

1) LLE Review **28**, 155 (1986).

2) J. Delettrez, **et al.**, Paper D5, 16th Anomalous Absorption Conference (1986).

"This work was supported by the U.S. Department of Energy Office of Inertial Fusion under agreement No. DE-FC08-85DP40200 and by Sponsors of the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics."

Time-Resolved Spectroscopy of Laser-Driven Spherical Targets

D. K. Bradley (LBL), P. Audebert, J. Delettrez, R. Epstein,
G. Gregory, B. L. Henke (LBL), P. A. Jaanimagi,
M. C. Richardson, and B. Yaakobi (LLE)

Time-resolved emission and absorption spectroscopy has been used to diagnose conditions within the shell before and during implosion of spherical targets irradiated at ~. 10^{14} W/cm^2 by 24 UV beams of the OMEGA laser system. Comparisons will be made with data recorded using a space-resolving spectrograph. The results will also be compared to calculations by hydrodynamic and atomic physics codes.

*Lawrence Berkeley Laboratory, Berkeley, California

"This work was supported by the U.S. Department of Energy Office of Inertial Fusion under agreements No. DE-FC08-85DP40200 and by the Sponsors of the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics. The research and materials incorporated in this work were partially developed at the National Laser Users Facility at the University of Rochester's Laboratory for Laser Energetics."

Time-Resolved X-ray Diagnosis of the Acceleration Phase of ICF Implosions

P. A. Jaanimagi, G. G. Gregory, D. K. Bradley (LBL),
J. Delettrez, F. J. Marshall, P. W. McKenty,
M. C. Richardson, and C. P. Verdon (LLE)

Time-resolved x-ray diagnostics are very important for studying the implosion dynamics of ICF targets. In this paper we will discuss our studies of the various phases of the implosion of targets uniformly illuminated with the 24 UV-beam OMEGA laser system at LLE. Previous experiments at LLE indicated good agreement with LILAC hydrocode simulations through the acceleration phase of the implosion, with a loss of symmetry attributed to shell break-up and/or burnthrough during the deceleration phase. We are now developing techniques to study these phases in more detail.

*Lawrence Berkeley Laboratory, Berkeley, California

"This work was supported by the U.S. Department of Energy Office Of Inertial Fusion under agreements No. DE-FC08-85DP40200 and by the Sponsors of the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics."

~~D8~~
D1

High-Density Direct-Drive Gas Filled Target Implosions

M. C. Richardson, P. Audebert, D. Bradley (LBL),
J. Delettrez, G. G. Gregory, P. A. Jaanimagi, R. Keck,
R. Kremens, F. J. Marshall, R. L. McCrory,
P. W. McKenty, J. M. Sources and C. P. Verdon (LLE)

This paper will review the status of an ongoing investigation of the performance of high-pressure, pusher-ablator targets driven by modest UV (351 nm) energies (1.5 kJ) from the 24 beam OMEGA laser facility. Comprehensive array of plasma, x-ray and nuclear diagnostics characterize the coronal plasma, the hydrodynamics of the implosion, and the final core conditions. Emphasis at present is being placed on examining the symmetry and stability of the target in the final stages of the implosion, the diagnosis of the fuel and shell conditions at the time of thermonuclear burn, and the proximity of these measurements to the predictions of one- and two-dimensional hydrodynamic code simulations. Data from several diagnostic techniques supporting the generation fuel densities in excess of 30 XLD will be presented. The influence of illumination non-uniformities on target performance will be discussed.

*Lawrence Berkeley Laboratory, Berkeley, California

"This work was supported by the U.S. Department of Energy Office Of Inertial Fusion under agreements No. DE-FC08-85DP40200 and by the Sponsors of the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics."

Effect of Mixing on Interpretation of Reaction Product Measurement of ρR

L. M. Goldman (LLE)

The introduction of non hydrogenic atoms in the the burning fuel mixture, due to mixing greatly complicates the use of the Gamalii, Krokhin[1] method (DT/DD neutron ratio) in determining ρR in a burning pellet. In particular, the extention of the method to include the measurement of the He_3 proton ratio no longer gives a unique measure of the temperature when mixing occurs. One can find self consistent solutions, however, if an independent measurement of the fuel electron temperature is determined. Measurement of the DD/DT neutron ratio, the DD neutron/to He3 proton ratio and the electron temperature could provide a unique prediction of ρR and the mixing ratio. Several potential cases will be discussed.

1. E.G. Gamalii, S.Yu. Guskov, O.N. Krokhin, V.B. Rozanov, JETP Lett. 21, 70 (1975).

"This work was supported by the U.S. Department of Energy Office Of Inertial Fusion under agreements No. DE-FC08-85DP40200 and by the Sponsors of the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics."

High Speed Detection of Thermonuclear Neutrons With Solid-State Detectors

D. R. Kania, S. Lane, B. Jones, and C. Bennett (LLNL)

With solid state detectors, we have achieved subnanosecond time resolution in the measurement of thermonuclear neutrons from direct-drive DT pellet implosions. In these experiments, 18-22 kJ of 0.35 μm light from the Nova laser are used to drive the implosions producing > 1e 12 neutrons. The solid state detectors are small cubes of neutron damaged GaAs mounted at the end of a small semirigid coaxial cable (FWHM = 60 ps). The detectors are enclosed in an x-ray and EMP shielded housing and have been mounted as close as 6 cm away from the target. the timing of the detector signal relative to the laser pulse is a direct measure of the implosion time and the width of the detector pulse places an upper bound on the neutron pulse width. The detector pulse width is limited by our ability to record a single shot electrical signal with a speed in excess of 200 ps. We will discuss the details of our techniques to increase the speed of our detection system.

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

New Approach to Diagnosis of Fuel-Pusher Mixing in Inertial Confinement Target

H. Azechi, R. O. Stapf, N. Miyanaga, M. Yamanaka, S. Ido,
K. Nishihara, Y. Kitagawa and C. Yamanaka (Osaka University)

A new approach[1)] to diagnosis of fuel-pusher mixing at the final phase of implosion is presented. This diagnosis involves detecting DT-neutrons [2,3)] and D^3He-protons [2)] (secondary reaction products) generated in a pure deuterium fuel.

If there is a significant energy loss of the DD-tritons and DD-^{3}He nuclei (primary reaction products) in the fuel, the DT cross section increases compared to the value at the triton birth energy, whereas the D^3He cross section decreases almost immediately. As the energy loss is enhanced by enriched electrons due to possible fuel-pusher mixing, the difference of the DT and D^3He fusion yields can be used to determine the mixing degree (pusher density mixed in fuel/total density in fuel). This quantity cannot be diagnosed by the usual x-ray backlighting or spectroscopy.

1)H. Azechi et. al., Bull. Am. Phys. Soc. 31, 1417 (1986).

2)H. Azechi et. al., Appl. Phys. Lett. 49, 555 (1986).

3)M. D. Cable et. al., Bull. Am. Phys. Soc. 31, 1461 (1986).

*The calibration of D^3He-proton detector has been carried out at the Research Center for Nuclear Physics, Osaka University

D9

Nonlinear Mode Coupling of the Rayleigh-Taylor Instability in Laser Ablatively Accelerated Targets

Mark H. Emery and John. H. Gardner (NRL)

We present the results from a series of numerical simulations of nonlinear mode coupling of the Rayleigh-Taylor(RT) instability using our FAST2D Laser Matter Interaction Model. We simulate the evolution of 8 - 20 modes impressed on the surface of thick (55 μm and 150 μm) planar CH targets accelerated by moderate (7×10^{13} W/cm^2) and high (3×10^{14} W/cm^2) intensity green (1/2 μm) and blue (1/4 μm) laser light. A grid structure as large as 200 x 200 mesh points is used to accurately resolve the mode structure.

The results indicate that nonlinear mode coupling occurs early in the evolution of the instability as evidenced by the reduction in the wavenumber dependence on the growth rate for the multimode case as compared to the single mode perturbation case. Wavelengths in the range of 40 - 60 μm dominate during the initial growth; however, the nonlinear interaction between the vortices results in the eventual dominance of large scale motion. This inverse cascading of energy toward the larger spatial scales drives the RT instability toward ~~progressively longer~~ wavelengths and limits the growth of the shorter wavelength perturbations. The longest wavelength mode is dictated by the computational grid. A striking result is that the planar target appears to be self-healing. The vortices couple in such a way so as to cause the spikes to collapse over the thinnest portion of the target (a large bubble) thereby regenerating a reasonably flat target which is uniformly accelerated. Density, velocity and vorticity contours will be presented to show the details of how the multimode RT instability evolves in time.

Work supported by the U. S. DoE and ONR.

Rayleigh-Taylor Instability Growth Rates in Targets Accelerated by an ISI-Smoothed Laser Beam

J. Grun, M. H. Emery, C. K. Manka, T. Y. Lee, E. A. McLean,
A. Mostovych, J. Stamper, S. Bodner,
S. P. Obenschain, B. H. Ripin (NRL)

Growth rates of the Rayleigh-Taylor (RT) instability in foils accelerated with a 1.053-um wavelength, ISI-smoothed laser beam are measured and compared with FAST2D hydrodynamic code simulations. RT growth rates are 0.6 of classical for the 150 and 100-um wavelength modes, in agreement with FAST2D simulations.

No RT growth is observed at the 50-um wavelength mode. FAST2D predicts that ISI can influence the 50-um Rayleigh-Taylor mode by delaying the start of its growth. This delay seems to occur because early in the laser pulse, when the critical and ablation surfaces are near each other, random fluctuations in the absorbed irradiance create random and fluctuating vortex structures on the ablation surface. These random vorteces may dominate the flow and increase the time for the flow patterns to evolve into an eigenmode. We will discuss whether this can explain the observed lack of growth at the 50-um wavelength mode.

This work is supported by the Dept. of Energy.

Evidence of Rayleigh-Taylor Instabilities in Tri-Layer Experiments

P. Holstein, B. Meyer, M. Rostaing, J. Bruneau,
N. Wilke, D. Galmiche, and J. P. Nicolle (CEL-V)

Mixing in multilayer planar target has already been studied /1/ . Basically Al-Au disks are accelerated by laser and so Rayleigh-Taylor instabilities occurs at the interface Al-Au.The instabilities generate a mixing of Al with Au at the rear of the target (Au side). By irradiating the rear of the target with a second laser beam the Al layer is heated and emits X-ray lines. In fact we used an tri-layer Au-Al-Au target in order to smooth the laser non-uniformities and to avoid Al X-ray lines emission coming from the front.

In this experiment we compare Al lines emission in the case of standard Au density and in the case of Au foam of Al density. On the other hand we used a 'curved cristal spectrograph with temporal resolution ;the time at which Al lines appears is connected to non-polluted Au thickness and the intensity of the lines is connected to the concentration of Al .We compare the experimental results to our 1D hydrocode coupled with an Al-lines postprocessor.

/1/ A.Raven,H.Azechi and al. P.R.L 47,15(1981) p1049

Pressure Preheat and Planarity of Nova Direct-drive Experiments

J. D. Kilkenny, D. W. Phillion, D. Munro,
P. Young, and R. P. Drake (LLNL)

Aluminum and plastic witness plate targets are strongly shocked by 0.35 μm laser light between 10^{14} and 10^{15} W cm^{-2}. The scaling of the ablation pressure with irradiance is measured by the shock velocity. A novel technique of a staircase target shows that the shock velocity is constant to a few percent. Gated optical images show the uniformity of shock velocity.

In comparing experimental results with simulations, the observations of absorptions exceeding 90% forces us to abandon flux limits. The measured ablation pressures then are 20% less than expected. The functions responsible for this small discrepancy are scrutinized. The most likely is uncertainty in the laser irradiance.

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

Session E

(Review)

The Application of Ray-Tracing Techniques To Laser-Plasma Simulations

R. S. Craxton (LLE)

Tuesday, 7:30 PM

Chairman: W. C. Mead (LANL)

The Application of Ray-Tracing Techniques to Laser-Plasma Simulations

R. S. Craxton

When a plasma is subjected to laser irradiation, two interacting processes must be modeled, namely the laser propagation through the plasma and the hydrodynamic response of the plasma to the laser. It is difficult to provide, simultaneously, accurate treatments for both processes, one reason being that the associated scale lengths differ widely. It is usually necessary to use a simplified model for at least one of these processes.

One approach is to use a full hydrodynamic simulation code with the laser propagation described by geometrical optics (i.e., raytracing rather than the wave equation). This treatment provides a practical means of investigating a wide variety of laser-plasma interaction problems in which refractive effects are important, including thermal self-focusing, the self-consistent calculation of absorption on tangentially irradiated spherical targets, and oblique-incidence flat-target experiments. Several illustrative simulations will be presented, with the emphasis placed on time-dependent effects. The ray-tracing approach will also be compared with other treatments which include more sophisticated propagation physics but less realistic hydrodynamics.

"This work was supported by the U.S. Department of Energy Office Of Inertial Fusion under agreements No. DE-FC08-85DP40200 and by the Sponsors of the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics."

Session F

(Poster)

All Topics

Tuesday, 8:30 PM

Gamma Ray Production in CO_2 Laser-Plasma Irradiation

G. D. Enright, N. K. Sherman, and N. H. Burnett (NRC)

We have observed gamma ray emission from CO_2 laser produced plasmas at irradiances of ~5 x 10^{15} W/cm^2 using a threshold detector. The detector is sensitive to photons of energy greater than 2 MeV. It consists of a moderated photoneutron detector which employs a heavy water converter and a Gd-loaded liquid scintillator. The detector must be heavily shielded both against previously observed hard x-ray emission in the 100-500 keV range and background neutrons from (p,n) reactions.

The initial measurements appear to be consistent with extrapolation of previous hard x-ray measurements although the anisotropy in emission is much more evident with the γ-emission peaked back toward the laser.

Holographic Polarimetry

C. C. Gomez (LANL)

Measuring the change in polarization of a probe beam passed through a plasma represents a powerful diagnostic technique. Traditionally this has been used to try to measure the magnetic fields present in ICF plasmas. By measuring the amount of rotation of a linearly polarized wave (due to the Faraday effect) an estimate of the magnetic field can be made. In real plasmas, Faraday rotation is not the only mechanism that changes the polarization of the light. In general a probe beam that is initially linearly polarized will have an elliptical polarization after interacting with the plasma. Present polarimetry systems used in ICF require the probe beam to maintain a high degree of linear polarization. This introduces an uncertainty in the interpretation of the polarization measurements, since it can not differentiate between a linearly polarized wave and one that is elliptically polarized. A need exists for the development of a technique which will measure the complete state of polarization of the wave. This has several advantages 1) it resolves the ambiguity inherent in present polarimetry systems in that it can resolve between linear and elliptical polarizations 2) the measured degree of ellipticity can be used as an additional diagnostic to the measurement of the angle of rotation. In plasmas, the degree of ellipticity can be affected by the density gradients present as well as to some extent by any **B** field perpendicular to the beam. Knowledge of the degree of ellipticity, may give us information about the other processes. A diagnostic such as the one described here can be of great value in unraveling these various effects.

A technique is proposed by which the polarization state of the wave can be holographically recorded. A similar method has been discussed by Lohmann [‡]. Two reference beams are used to record the hologram; they are incident at different angles and their polarizations are perpendicular to each other. Each reference beam interferes with the polarization component in the object beam parallel to itself, thus making two multiplexed recordings, one for each polarization state. On reconstruction two beams are used at the same angles of incidence and polarization as the reference beams. The reconstructed waves from each beam interfere with each other so as to reproduce the polarization state of the object beam.

Analysis of the technique as well as consideration in applying it to ICF plasmas will be presented.

[†] Supported by DOE

[‡] A. W. Lohmann, Appl. Opt. **4**, 1667 (1965)

F3

Superathermal Electron Production in a Magnetized Plasma

C. Domier and N. C. Luhmann, Jr. (UCLA)

Suprathermal electron production near the critical layer ($n_e/n_c \sim 1$) is studied in a cylindrical, weakly magnetized ($\Omega/\omega < 0.02$) pulsed filament discharge (88 cm length, 60 cm diameter). Typical plasma parameters during the discharge are: $n_e = 1.3 \times 10^{11} cm^{-3}$, $T_e \sim 2.5 eV$ and $T_i/T_e \sim 0.1$ for an argon neutral gas pressure of $\sim 5 \times 10^{-4}$ Torr. The magnetic field, less than 20 G, is produced by two coils outside the chamber and is perpendicular to the axial density gradient.

Electromegnetic waves with frequency $f_o = 3.3$ GHz and maximum power 120 kW are launched along the chamber axis from a high gain horn antenna located at the low density end of the chamber. In the presence of the external magnetic field, suprathermal electrons are accelerated across the density gradient near the critical layer for resonance absorption. The high energy lectrons produced have directionality with respect to the magnetic field and have energies in excess of those produced by resonance absorption alone. The mechanism involved is thought to be $V_p x B_o$ acceleration(1). Results will be presented concerning scaling with power and background suprathermal electron distribution.

*Work supported by the Lawrence Livermore National Laboratory Laser Fusion Program.

(1) Y. Nishida, M. Yaoshizumi and R. Sugihara, Physics Letters 105A, 300 (1984).

Energy Absorption of Subpicosecond Very Intense Laser Pulses

F. Brunel (NRC - Canada)

Very strong absorption is observed from electromagnetic 2½D particle (PIC) electromagnetic simulations when a very intense laser pulse is obliquely incident on an overdense plasma surface, due to a large number of electrons that are dragged into the vacuum and sent back into the plasma with velocities on the order of the quiver velocity. A corona is not needed for $I \gtrsim 4 \times 10^{16}$ W $\mu m^2/cm^2$, and the absorption becomes efficient even for very short laser pulses. Good agreement[1] has been found with a previous one dimensional electrostatic model[2], for the absorption level as well as the hot electron temperature, in the case where the incident pump is split into two equal components incident at equal and opposite angles: this geometry minimizes the v x B force term effects. In the case where the laser pulse is incident from one direction only, a reduction in the absorption level is observed[1]; we also observe strong average current density that establishes itself in the vacuum region along the surface with a return current in the skin depth region: an average magnetic field will appear such that an average v x B force term will partly neutralize the electrostatic forces between the electrons, and may possibly inhibit to some extent the return of the hot electrons into the plasma.

References

1. See also K. Estabrook and W.L. Kruer, Laser Program Annual Report, University of California, Livermore, CA. 1987, Sect. 2.3.11.
2. F. Brunel, submitted to Phys. Rev. Letters.

Alternative Analysis of CO_2-Laser-Produced Plasma Waves

A. Simon, R. W. Short, W. Seka, and L. M. Goldman (LLE)

Two recent experiments[1,2] at U.B.C. using a probe beam have obtained time-resolved features of the plasma wave spectrum in a gas jet target irradiated by a CO_2 laser. Their interpretation of these waves as being the product of the SRS instability leads to some difficulties with the onset threshold and the number of hot electrons as well as with the absence of the corresponding scattered Raman light. There are also problems with the identification of the density at which the probe scattering occurs, and with the direction of propagation of the plasmons and of the wave vector spectrum.

We will show that these difficulties are removed by an alternative interpretation in which the waves are generated by pulses of fast electrons originating at the $n_c/4$ surface[3,4]. A unique relationship between probe scattering angle and plasma density is derived which is quite different from that of the SRS model and which varies in the opposite sense.

1. G. McIntosh, H. Houtman, and J. Meyer, PRL 57, 337 (1986).
2. G. McIntosh, J. Meyer, and Z. Yazhou, Phys. Fluids 29, 3451 (1986).
3. A. Simon and R.W. Short, PRL 53, 1912 (1984).
4. A. Simon, W. Seka, L.M. Goldman, and R.W. Short, Phys. Fluids 29, 1704 (1986).

"This work was supported by the U.S. Department of Energy Office Of Inertial Fusion under agreements No. DE-FC08-85DP40200 and by the Sponsors of the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics."

Gradient Stabilization of Ion-Electron Streaming Instabilities in Heavy Ion Fusion

Dennis W. Hewett and William L. Kruer (LLNL)

Heavy ion beams have been proposed as an efficient candidate for use as an Inertial Confinement Fusion driver but many details of their interaction with high density targets require further study. We have begun modelling the various instabilities driven by the velocity anisotropy of the ions. We are particularly concerned with beam degradation during transport to the target. We use the Direct Implicit Code AVANTI[1] to study one aspect of this problem--the gradient stabilization of the beam ion-background electron streaming instability.

We consider a tenuous ion beam moving through a neutralizing background plasma with arbitrary inhomogeneity. Implicit PIC methods overcome the time step constraint resulting from the tremendous range of densities this problem encompasses. Explicit methods are forced to resolve plasma oscillations in the highest density regions, even when these plasma oscillations only occur in the lower density region. A further problem for fully electromagnetic models is the CFL limit on light propagation. Our implicit PIC method relaxes these restrictions and makes feasible problems with density ranges due to strong gradients that would otherwise be untenable.

The ion background density is 10 on the left boundary of our simulation followed by a linear density profile with arbitrary gradient. The ion beam density is uniform throughout the simulation with unit density. The electron background is chosen to provide charge neutrality initially and is given a small drift so that the initial configuration has no net electric current. No zeroth order confining fields are considered. We first establish a strong electron-ion two stream instability in a homogeneous plasma and then stabilize the instability with finite density gradients. We will present results from this investigation and discuss some subsequent low frequency phenomena which fully exploit the implicit code.

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[1] D.W. Hewett and A.B. Langdon, UCRL 94591 (J. Comp. Phys., August, 1987).

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

F7

Numerical Studies of Ultra-Strong Langmuir Turbulance

J. P. Sheerin (KMS Fusion, Inc)

The usual description of strong Langmuir turbulence (the so-called Zakharov equations), predicts the formation of solitons and their subsequent collapse. Numerical simulations as well as self-similar solutions of the Zakharov model indicate the occurrence of wavebreaking in the later stages of collapse, during which time the assumptions (e.g., low frequency quasineutrality, small wave intensities relative to background thermal pressure small density perturbations, spatial scales much greater than a Debye length) inherent in Zakharov-type models, break down. To investigate such phenomena, we have presented a full two-fluid model of Langmuir collapse without the restrictions imposed by the usual assumptions (1). A parametric analysis of this model indicated the occurrence of a modulational instability as expected. Comparisons with the Zakharov model demonstrate the importance of the finite pressure term. Current studies of this model focus on numerical simulations of the evolution equations. Comparisons both qualitative and quantitative, are made with the Zakharov model for certain idealized cases.

(1) J. P. Sheerin, D. R. Nicholson, and G. L. Payne,
B.A.P.S., 31, 1446(1986)

Kinetic Effects in the Evolution of Localized Langmuir Waves

W. Rozmus, J. C. Samson, and R. Teshima (University of Alberta)

The results of numerical and analytical studies of the interaction of electrons with localized Langmuir waves will be presented. The electrostatic fields are calculated using a model which describes simultaneous Raman and Brillouin scattering. The model includes nonlinear evolution described by the Zakharov equations. The evolution of the electron distribution function is analyzed by using numerical codes to compute the particle dynamics, and by solving the kinetic equation. The effects of the modified electron distribution function in changing the damping rates and frequencies of the Langmuir waves are also considered. These results will be compared with a quasi linear diffusion model. Kinetic effects in the collapse of the Langmuir waves will also be discussed.

Competition Between Forward Raman and Backward Brillouin Instabilities

M. Casanova (CEL-V)
and
D. Pesme (Ecole Polytechnique-Palaiseau)

The problem of laser interaction is studied in a well underdense plasma in which the main competing mechanisms are stimulated Brillouin scattering and stimulated Raman forward scattering. Thresholds, growth times and growth lengths are first given for the two instabilities. As regards what is the dominant instability, the comparison is then made between the predictions deduced from the previous linear analysis and the numerical results obtained from a mode coupling code in which Raman and Brillouin instabilities are simply dealt with in the limit of the envelope approximation.

Role of Langmuir Wave Non-Linearities in Stimulated Raman Scattering (SRS)

G. Bonnaud (CEL-V)
and
D. Pesme (Ecole Polytechnique-Palaiseau)

The non-linear evolution of SRS is studied numerically. A mode-coupling type code has been designed, aimed at investigating the role of the coupling of ion dynamics to SRS. Use of either the complete propagators or envelope approximations can be made, making it possible to investigate separately each of the various effects induced by ion dynamics (decay of plasma waves, stimulated Brillouin scattering (S.B.S.), modulational instability and collapse). Special interest is given to the role of the nucleation of the plasma waves, by comparing the SRS reduction induced by nucleation, with the SRS reduction due to the simple SRS/SBS competition and to the decay of plasma waves.

Session G

(Oral)

Raman Scattering

Wednesday, 9:00 AM

Chairman: D. Pesme (Ecole Poly.)

Raman Emission with ISI

S. P. Obenschain, K. J. Kearney, C. K. Manka, A. N. Mostovych,
C. J. Pawley, J. Grun, J. A. Stamper (NRL), and D. R. Kania (LLNL)

Raman emission with and without induced spatial incoherence (ISI)[1] was studied using a 1053 nm laser with adjustable bandwidth focused onto plastic and gold targets. Arrays of germanium and indium arsenide detectors monitored the light emission from 2200 to 1400 nm at angles of 0° and 8° with respect the axis of the laser beam. When using a single 300J laser beam focused to intensities below 1.2×10^{14} W/cm^2, ISI quenched the Raman emission over the 1800-1400 nm range, leaving only the blackbody emission from the plasma. At similar laser energies and average intensities, both a plain laser beam and a narrowband beam with ISI echelons produced orders of magnitude higher emission over this wavelength range.

To reduce the Raman threshold, we employed a second laser beam with a large (1 mm) focal diameter to produce a long scalelength plasma target for the high intensity beam. With the preplasma, we could observe Raman emission with ISI. Parametric studies of this interaction and a discussion of mechanisms whereby ISI might affect the Raman instability will be presented.

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

1. R.H. Lehmberg and S.P. Obenschain, Opt. Commun. 46, 27 (1983).

Beyond the Zakharov Model: The Collapse of SRS-Excited Langmuir Waves Initiated by Their Nonlinear Steepening

B. Bezzerides, C. H. Aldrich, D. F. DuBois, H. A. Rose (LANL)

Recent work has demonstrated the role of caviton collapse in the saturation of Langmuir waves excited by stimulated raman scatter (SRS) in laser-plasma interaction experiments.[1] In the presence of stimulated Brillouin scatter (SBS) the collapse follows the initial modulation of the Langmuir waves by the excited ion density wave.[2] For weak SBS the Langmuir waves may still collapse, having first become modulationally unstable. Both these paths to collapse rely on the mobility of the ions and have been successfully analysed by use of the Zakharov model.

Ignoring ion mobility the Langmuir waves will ultimately steepen and break saturating through hot-electron generation. We present the results of particle simulations and numerical analysis to show that the ponderomotive force of nonlinearly steepened Langmuir waves can drive a periodic density response which again modifies the time evolution of SRS leading to the collapse and burnout scenerio previously seen. The description of this effect goes beyond the Zakharov model. These results argue that the hot-electron spectrum may be a composite resulting from the joint effects of ordinary wave-breaking and caviton collapse.

1. C.M. Aldrich, B. Bezzerides, D.F. DuBois, and Harvey A. Rose, Comments on Plasma Phys, and Contr. Fusion 10, 1, 1986.

2. Harvey A. Rose, D.F. DuBois, B. Bezzerides, Nonlinear Coupling of Stimulated Raman and Brillouin Scattering in Laser-Plasma Interaction, Los Alamos National Laboratory Report LA-UR-86-3706(1986).

Transition Regime in the Coupling of SRS and SBS in Slab Geometry

Harvey A. Rose, D. F. DuBois, and B. Bezzerides (LANL)

It has been shown, both in periodic(1) and slab(2) geometry that an exponentially growing ion sound wave may detune and effectively kill the SRS instability. As the plasma density is lowered from quarter critical, one encounters a transition range of densities in which the saturated level of SRS activity is rapidly increasing. With a reasonable choice of slab length, qualitative agreement concerning the location, breadth, and other features of this transition regime, is obtained with the experiments of Walsh et al.(3) The result of any particular experimental realization is very sensitive to all the physical parameters, including uncontrollable thermal fluctuations. Plasma inhomogeneities tend to smooth out this transition regime.

In PIC simulations, the ion fluctuations have a level which cannot easily be reduced to that appropriate for many experiments, and as a result the SRS transition regime will be skewed toward lower density values than actually observed.

Even at densities low enough so that SRS always reaches a strong level, details of the ion fluctuations may have an important effect on the level reached.

(1) "Langmuir Nucleation and Collapse in Stimulated Laser LIght Scatter," with B. Bezzerides and D. F. DuBois, Comments in Plasma Physics and Controlled Fusion X 1, (1986).

(2) "Nonlinear Coupling of Stimulated Raman and Brillouin Scattering in Laser-Plasma Interaction," with D. F. DuBois and B. Bezzerides, LA-UR-86-3706 (submitted to Phys. Rev. Lett.).

(3) C. J. Walsh, D. M. Villeneuve and H. A. Baldis, Phys. Rev. Lett. 53, 1445 (1984).

* Supported in part by U.S.D.O.E.

Growth and Collapse of Langmuir Waves from Stimulated Raman Scattering

D. M. Villeneuve, H. A. Baldis and J. E. Bernard (NRC-Canada)

We have used Thomson scattering techniques in a preformed plasma to measure the temporal evolution of plasma waves driven by SRS. Ion and plasma waves were imaged by a streak camera. The plasma waves started early in the laser pulse and extended over more than a millimeter of plasma, slightly towards the pump side of the parabolic density profile (in agreement with predictions of T. W. Johnston).

The plasma waves grew rapidly for ~50 ps, then quenched rapidly, quickly followed by SBS ion waves. When the k-spectrum was streaked, it showed the presence of harmonics. A framing camera recorded the plasma wave level in (ω, k) space, and showed components at $(l\omega_p, mk_p)$, where ω_p is the plasma frequency, $k_p \approx 1.7k_0$ is the SRS plasma wavenumber, and l and m are integers. With a weak pump, only $(l = 1, m = 1)$ was apparent, but with a strong pump high levels of $l = m$ components up the the 3rd harmonic appeared. In addition some weaker signals at $(l = 1, m = 2, 3)$ were seen.

The frequency harmonics at $l = m$ are a signature of plasma wave steepening which precedes the Langmuir collapse (predicted by Aldrich, Bezzerides, Dubois and Rose, ABDR). The $(l = 1, m = 2, 3)$ components are also related to the ABDR model and act as a seed which initiates SBS ion waves.

G5

Observation of Steepening in Electron Plasma Waves Driven by Stimulated Raman Backscattering

D. Umstadter, R. Williams, C. Clayton, and C. Joshi (UCLA)

Electron plasma waves driven to large amplitude by the Raman backscatter instability SRS) are of current interest because of their potential to accelerate electrons to high energies and in connection with plasma instabilities. SRS occurs when an incident light wave beats with a light wave which is reflected in the backward direction from plasma noise. A feedback loop is created when the ponderomotive force due to the beating electromagnetic waves excites a longitudinal plasma oscillation which in turn reflects light more strongly and thus may hinder the absorption of laser energy by the plasma. One of the basic results of a fully nonlinear theory is that electron plasma waves steepen as they grow until they eventually reach either saturation or wavebreaking. Wavebreaking is thought to be the origin of hot electrons which may preheat the laser fusion fuel and thereby reduce compression efficiency. Steepening is equivalent to an increase in the amplitudes of higher harmonic components of the perturbed density relative to the fundamental. In this paper we report the direct experimental observation of the harmonics of SRS driven plasma waves using frequency and wavenumber resolved ruby Thomson scattering. Measurements

of their relative amplitudes agree with predictions of nonlinear warm plasma wave steeepening theory[1] up to the maximum observed amplitude of the fundamental component, $\tilde{n}_1/n_0 = 16\%$. A 10.6μm, CO_2 laser ($I\lambda^2 = 7.9 \times 10^5$) was focussed onto an arc preionized H_2 plasma in order to excite the plasma waves. Thomson scattering was performed using a 1 J, 15 ns ruby laser pulse ($\lambda = .6943\ \mu$m). The backscatter and Thomson scatter spectra were frequency and amplitude analyzed. Both of the decay products of SRS, the daughter light wave and the plasma wave fundamental, were detected simultaneously and found to be correlated in both frequency and amplitude.

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[1] L. S. Kuz'menkov et al., Izv. Vyssh. Uchebn. Zaved., Fiz., 12, 17 (1983) [Sov. Phys. J. 26, 1076 (1984)].

Absolute Stimulated Raman Backscatter at High Laser Intensities

R. W. Short and A. Simon (LLE)

The eigenmodes for absolute stimulated Raman backscatter in a linear density profile have been calculated accurately for the first time, with some surprising results. Among them: at high incident laser intensities ($v_0/c \geq .05$) there are discrete modes which have growth rates substantially larger than the SRS growth rate in a homogeneous plasma. The backscattered wave is trapped near quarter-critical density, however, so that no detectable backscattered light is produced. These modes resemble the "resonant" modes inferred from an approximate analytical treatment of absolute SRS by Drake and Lee[1], though there are significant differences. The required intensities are commonly reached in CO_2 laser experiments, and these trapped modes may account for the otherwise puzzling observations reported by Villeneuve, Walsh and Baldis[2] in a CO_2 experiment in 1985. They used Thomson scattering of a probe beam to detect plasma waves corresponding to absolute SRS at quarter-critical, and yet saw no backscattered CO_2 light, even though the observed level of plasma waves should have corresponded to a backscatter intensity several orders of magnitude above the detection threshold.

1. J.F. Drake and Y.C. Lee, Phys. Rev. Lett. 31, 1197 (1973).
2. D.M. Villeneuve, C.J. Walsh, and H.A. Baldis, Phys. Fluids 28, 1591 (1985).

"This work was supported by the U.S. Department of Energy Office Of Inertial Fusion under agreements No. DE-FC08-85DP40200 and by the Sponsors of the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics."

G7

Nonlinear Theory of Absolute Raman Instability at the Quarter Critical Density

P. Guzdar, Y. C. Lee, and
Chuan Sheng Liu (University of Maryland)

A nonlinear theory for absolute Raman instabilities at the quarter critical density is developed, including the nonlinear effects of ponderomotive forces due to plasma waves and reflected light waves. Nonlinear effect on the density profile and subsequent development of the instability are demonstrated. The nonlinear density cavity is saturated at $\delta n_{NL}/n_0 \sim 3\%$. Reflectivity is saturated at $0.27(1 + Z\, T_i/T_e)/Z$. A nonlinear saturated spectrum and hot electron production rates are also obtained.

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*Also affiliated with the Department of Physics and Astronomy at the University of Maryland.

Stimulated Raman Scattering in the Presence of Long Wavelength Density Fluctuations

B. B. Afeyan, J. F. Drake, Y. C. Lee,
and C. S. Liu (University of Maryland)

SRS in the presence of density fluctuations is treated by solving the appropriate initial value problem numerically. Of special interest is the question of the mechanism for transition from convective to absolute instability as the quarter critical surface is approached. The effects of spatial density fluctuations on this transition are examined to help elucidate the physics behind the Nicholson and Kaufman results.[1] Their work, which uses the Rosenbluth model equations, shows that for sufficiently long wavelength fluctuations, and above a certain fluctuation amplitude, convective modes become localized. In our model, the inhomogeneity is in 1-D but two dimensional scattering geometries are allowed. We do not make the eikonal approximation. The transition from smooth to quasiperiodic to randomly fluctuating density profiles are considered. The difference in the thresholds of these various cases will be shown.

*Work sponsored by Naval Research Laboratory.

1. D. R. Nicholson and A. N. Kaufman, Phys. Rev. Lett. 33, 1207 (1974); D. R. Nicholson, Phys. Fluids 19, 889 (1976).

Enhanced Thomson Scattering in Underdense Targets

A. Simon and R. W. Short (LLE)

Experiments using thin foils[1], which drop below n_c and even $n_c/4$ early in the pulse, have shown the same agreement as is seen for thick targets between the observed Raman spectrum and the predictions of the bump-on-tail enhanced plasma wave theory[2]. This raises the issue of how long such directed pulses of fast electrons can continue to exist in the plasma after their source at n_c or $n_c/4$ disappears.

We will show that the classical degradation process is quite slow (of the order of 100 ps or more). Collective processes can broaden and flatten the beam on a faster time scale[3]. However, inclusion of finite spatial size strongly reduces the effect[4]. Furthermore, we will show that broadening of the beam has little effect on the predicted spectrum.

1. c.f.: H.Figueroa, et al., Phys. Fluids 27, 1887 (1984), or R.E.Turner, et al., PRL 57, 1725 (1986).
2. A. Simon, W. Seka, L.M. Goldman, and R.W. Short, Phys. Fluids 29, 1704 (1986).
3. V.N. Tsytovich, Nonlinear Effects in Plasma, Plenum, New York (1970).
4. M.M. Shoucri and L.R.O. Storey, Phys. Fluids 29, 262 (1986).

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Observations of Enhanced Thomson Scattering

S. H. Batha, L. M. Goldman, W. Seka, and A. Simon (LLE)

The presence of a non-thermal bump-on-tail electron temperature distribution gives rise to enhanced bands in the scattered light spectrum[1] of a laser-produced plasma that are shifted both up and down from the laser frequency. The positions of these bands are governed by the directed velocity of the electrons, the cold background temperature, and the ratio of the number of fast to cold electrons. The directed velocity is deduced from the measured superhot "temperature" of the x ray spectrum. We have observed simultaneous up- and down-scattering in recent experiments on the GDL system operating at 527 nm. Our results are consistent with the enhanced Thomson scattering theory using cold electron temperatures of from 800 to 1000 eV and hot electron "temperatures" of from 10 to 25 keV. We have verified these results with independent measurements of the electron temperature. Time resolved measurements of the down-scattered light will also be presented.

1. A. Simon, W. Seka, L.M. Goldman, and R.W. Short, *Phys. Fluids* **29**, 1704 (1986).

"This work was supported by the U.S. Department of Energy Office Of Inertial Fusion under agreements No. DE-FC08-85DP40200 and by the Sponsors of the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics."

Session H

(Review)

Progress in the Linear Theory Of Parametric Instabilities

E. A. Williams (LLNL)

Wednesday, 8:30 PM

Chairman: R. L. Berger (KMS Fusion)

Progress in the Linear Theory of Parametric Instabilities

E. A. Williams (LLNL)

The suggestion that thermonuclear fusion might be achieved by the irradiation of suitably designed pellets with laser beams caused a surge of theoretical activity in the early seventies.

Strong electromagnetic waves in plasma were shown to be unstable to the growth of pairs of decay waves satisfying certain frequency and wavenumber matching conditions. These "parametric" processes acquired individual names such as stimulated Raman and Brillouin scattering, have two plasmon decay and ion-acoustic decay instabilities. Thresholds and growthrates for infinite homogeneous plasma were determined, absolute and convective instabilities distinguished and the major effects of plasma and/or laser inhomogeneity were identified.

The more recent wave of theoretical interest in these instabilities has been inspired by their potential programmatic impact and by ever better diagnosed experiments. This has led to a deeper understanding of previous theory, more precise calculations and extensions to configurations of experimental interest such as exploding thin foil targets.

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

Session I

(Poster)

All Topics

Wednesday, 8:30 PM

Photoresonant Absorption and Line Spectra for Neon Plasmas

R. A. Walton, P. Filbert, J. Hawley,
D. Kohler, and J. D. Perez (Lockheed)

In this paper we present results from numerical simulations of x-ray line spectra for a noble gas plasma subjected to an incoherent, photoresonant source of x-rays. For our noble gas plasma we consider neon heated to a temperature where NeVII is the dominant species while for our photoresonant x-ray source we consider a beryllium plasma in which BeIV is dominant. The photoresonant absorption transition in NeVII is the 2p to 4s transition and the photoresonant x-rays are generated by the 2p to 1s transition in BeIV. This system of photoresonantly interacting plasmas is the basis for a laboratory x-ray laser currently being investigated at the Lockheed Palo Alto Research Laboratory.

Using the results of our numerical simulations we will discuss the effect of photoresonant absorption on the neon plasma's line spectra, both time-integrated and time-dependent. We will also discuss the effect on the neon plasma's line spectra due to photoionization by the BeIV photoresonant source. Comparison of our results with experimental spectra will be made.

This work is supported by the Lockheed Independent Research Program.

Analysis of Dot Spectroscopy Experiments

M. D. Rosen, B. K. Young, and R. E. Stewart (LLNL),
G. Charatis, and G. E. Busch (KMS Fusion)

A CH target, with a 100μm diameter Mg dot embedded in it, is irradiated with the KMS, 1 ns flat-top, 0.53μm laser at $7\text{X}10^{13}$ W/cm^2. Electron densities are determined by 4-frame holographic interferometry. Temperatures are derived from the free-bound continuum slopes of similarly irradiated $NaNO_3$ slabs. Spatially localized, time resolved H-like and He-like Mg lines are detected. employ 2-D hydro simulations with (non-steady state) kinetics postprocessors to analyze these data. Excellent agreement is obtained between theory and experiment for the time evolving density profiles, temperatures, and spectra. In particular the He-like to H-like n = 3 to 1 line ratio is matched quite well both during the laser pulse when $T_e \sim 950$ eV and the ratio is about 0.1, to well after the laser turns off when $T_e \sim 150$ eV and the ratio is about 2.

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

Rear-Side Heating of Laser Irradiated Thin Foils

R. Benattar and J. Godart (Ecole Polytechnique-Palaiseau)

Thin aluminium foils 10 μm and 25 μm thicknesses are illuminated by laser at 0.26 μm. We image with X-UV microscopes the rear side emission from these foils. We show, by recording the absorption of a probe radiation at 40 eV, that 25 μm thickness foils are heated before the break-through appears.

Time resolved X-UV emission of both parts of the foils (rear and front) gives the timing of the break-through and allows us to characterize the mechanism of preheat.

*contributing team to the GRECO ILM, Ecole Polytechnique, Palaiseau, (France).

Evolution of Laser Filaments in Fusion Plasmas

R. Rankin, R. Marchand, and C. E. Capjack (University of Alberta)

A two-dimensional hydrodynamic simulation code is used to study the spatial and temporal evolution of laser beam filaments in fusion type plasmas. The propagation of the laser beam is described by a paraxial wave equation which is solved numerically using cubic splines. Diffraction, ponderomotive forces, and heating processes are accounted for in a self consistent manner.

Effects of Induced Spatial Incoherence on Raman Scattering

A. Bourdier (CEA de Vaujours) and E. A. Williams (LLNL)

We report progress in developing a model to account for the effects of Induced Spatial Incoherence (ISI) on stimulated scattering instabilities.

Experiments at NRL[1] have shown substantial suppression of these instabilities by ISI, albeit at relatively low laser powers. We will focus on Raman scattering and see how the growth rate of this instability is reduced by combining the effects of spatial and temporal incoherence. In this investigation, we suppose that the effects of ISI can be primarily attributed directly to the change in the characteristics of the pump wave, and not to indirect effects on the evolution and smoothness of the target plasma. As a first step, we model the effect of the echelons as giving rise to an angular spread in the pump wave vector, and thus treat the pump as the sum of multiple overlapping beamlets. In a second part, we generalise our method. In order to describe Induced Spatial Incoherence better, we take into account an angular spread and a finite bandwidth. The effect of the bandwidth is to make the beamlets mutually more incoherent. If one averages over a long time compared to the laser coherence time (this time should be smaller than the growth time of our instability), the interference patterns from the overlapped beamlets are destroyed producing a smooth focal pattern. We use a relatively unsophisticated mathematical treatment, for simplicity, in this stage of the investigation.

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

** At the present time, Dr. Bourdier is a guest of the Lawrence Livermore National Laboratory.

[1] S. P. Obenschain, et. al., "Laser-Target Interaction with Induced Spatial Incoherence," Phy. Rev. Lett., 56, 26, p. 2802 (June 1986).

Measurements of SBS Spectra With ISI Illumination

A. N. Mostovych, C. K. Manka, S. P. Obenschain,
C. J. Pawley, J. Grun, and K. J. Kearney (NRL)

Measurements of SBS scattering with and without Induced Spatial Incoherence (ISI)[1] were made using a 1054 nm laser with adjustable bandwidth. The bandwidth was varied between .0002%, .01%, .06% and .13% and the irradiance on target was about 10^{14} W/cm^2. The observed SBS was confined to backscatter through the lens and for the case with ISI echelons and broad laser bandwidth (>.01%) the SBS intensity was reduced by as much as an order of magnitude relative to a non-ISI beam. If the laser bandwidth was reduced to .0002%, with the ISI echelons in place, then the backscatter intensity increased to about 10-20 times the broad band case and double the non-ISI case. We find that the effectiveness of ISI in suppressing the SBS instability is greater than would be expected from simple averaging of the laser hot spots. Quenching of SBS was observed even when the laser coherence time was made much larger than the convective saturation time of the SBS instability.

1. R.H. Lehmberg and S.P. Obenschain, Opt. Comm. ^{46}, 27 (1983).

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

SBS Spectra from Double-Foil Targets

L. V. Powers and R. L. Berger (KMS Fusion)

Double-foil target designs are employed to produce the relatively gentle plasma density gradient needed for studying plasma instabilities above threshold and for x-ray laser studies. The dominant mechanism in the interaction and heating of counterstreaming ion beams in these targets has not yet been clearly established. We investigate the use of the SBS signal from such flowing plasmas as a diagnostic of the collisionality of the interaction.

According to quasilinear theory, in the limit of collisionless flow only a small fraction of the ion kinetic energy goes into heating the plasma ions via the two-stream instability before the instability is stabilized at $ZT_e/T_i \sim 4$ [1]. The ion modes supported by the counterstreaming distribution at this marginal temperature act as a source for SBS. The SBS scattered spectrum consists of both an up-shifted and a down-shifted feature for $u/c_s \cos\theta \gtrsim 1$, where $\vec{u}$ is the flow velocity, c_s is the ion sound speed, and θ is the angle between the scattered light and the flow vector. In the opposite limit of collisional stagnation, the flow kinetic energy is converted to ion thermal energy. In this case the scattered spectrum near ω_0 is due to Compton scattering off stationary hot ions and consists of a single broad down-shifted feature [2].

The qualitative differences in the SBS spectrum in the two limits suggest that the SBS signal can be a useful diagnostic of flow physics in these counterstreaming plasmas. We will present comparisons of the homogeneous plasma SBS frequencies and growth rates for the two cases for a variety of parameters, including the case of unequal densities in the two ion beams.

1. E. A. Foote and R. M. Kulsrud, Phys. Fluids 24, 1532 (1981).

2. J. F. Drake, P. K. Kaw, Y. C. Lee and G. Schmidt, Phys.Fluids 17, 778 (1974).

Spatio-Temporal Energy Cascading in the Beat-Wave Accelerator

C. J. McKinstre, D. W. Forslund (LANL) and S. H. Batha (LLE)

In the beat-wave accelerator, the Langmuir wave is driven by the beating of the two incident light waves and any adjacent pair of their sidebands. Initially, energy is present only in the incident waves and the Langmuir wave is generated by the familiar three-wave interaction in which a higher-frequency photon decays into a lower-frequency photon and a plasmon. If the total energy transferred to the Langmuir wave is to exceed the Manley-Rowe limit, the laser energy must be made to cascade "downwards" from the incident light waves to their lower-frequency sidebands. A simple analytical estimate is given for the maximum amount of energy which can be transferred to the Langmuir wave in the wave-particle dephasing time. Some ways to bias the cascade downwards are also discussed. The analytical predictions are compared with numerical solutions of the governing equations and computer simulations.

Plasma-Wave Wigglers for Free-Electron Lasers

C. Joshi, T. Katsouleas, J. M. Dawson,
W. B. Mori, and Y. T. Yan (UCLA)

We explore the possibility of using a relativistic plasma density wave as a wiggler for producing free electron laser radiation. Such a wiggler is a purely electric wiggler with frequency ω_p (plasma frequency) but zero wavenumber k_p. If an electron beam is injected parallel to the plasma wave wavefront, it is wiggled transversely with an apparent wiggler wavefront

$$\lambda_w = 2\pi c/\omega_p .$$

Using plasma densities in the 10^{17} (cm^{-3}) range, λ_w of order 100 μm may be obtained thereby permitting generation of short wavelength radiation with modest energy beams. The effective wiggler strength $a_w = eA/mc^2 \sim 0.5$ can be extremely large. We discuss the excitation methods for such wigglers and examine the constraints imposed by the plasma medium on FEL gain in this scheme.

CO_2 Laser-REB Interaction "S Program"

Y. Kitagawa, K. Mima, H. Fujita, H. Nakajima,
H. Takabe, K. Nishihara, H. Azechi, K. Tanaka, C. Yamanaka (Osaka University),
and N. Ohigashi (Kansai University)

The CO_2 laser-REB Interaction "Σ PROGRAM" has two objects. The first is a REB scattering of a CO_2 laser light, i.e., upconversion of a 10-μm light to a visible light (a micro-wiggler FEL). The REB (500keV, 0.5kA, 60ns) backscatters the 10.6μm laser light (300J, 100ns incidence). We have obtained two spectral groups of the scattered lights, one of which varies as $\lambda_{CO_2} \cdot (c - v_b)/(c + v_b)$, where $\lambda_{CO_2} = 10.6\mu m$ and v_b is the REB velocity. The another one does not vary as v_b. The formar spectrum is a doppler-shifted FEL light (800~600nm, ~0.1μJ). The latter is also a FEL branch coupled to a carbon atomic resonance line (660nm) from the REB diode material.

The second is a laser-beat-wave acceleration of REB. 10.7μm and 9.6μm beams (100J/1ns each)are collinearly focused by an f/10 *NaCl* lens into a puffed and simultaneously discharged gas plasma, driving a beat-frequency plasma wave ($v_{os}/c \sim 0.1$). The REB is guided through a solenoidal field (10kG) into the interaction region, 1mm in diameter and 3mm in length, as collinearly as the laser beams. An electron spectrometer, consisted of a Sm-Co magnet and plastic scintillators, detects the electrons accelerated up to more than 10MeV. The hybrid code has simulated that a 330ps-Gaussian laser pulse accelerates the 0.5MeV REB to more than 10MeV. The experimental data are to be compared with the simulation.

Session J

(Oral)

Nonlinear Interactions

Thursday, 9:00 AM

Chairman: W. Rozmus (Univ. of Alberta)

Reflectivity from SBS for a Broadband Incident Light

A. Lesne, G. Laval, D. Pesme (Ecole Polytechnique-Palaiseau),
and M. Casanova (CEL-V)

The reflectivity of a bounded plasma is investigated analytically in the case of a broadband incident wave, within the Random Phase Approximation ; the effect of the damping of the ion sound wave upon the reflectivity is studied.

J2

Observations of Scattered Fundamental Light From Exploding Foil Plasmas

P. E. Young, R. P. Drake, D. L. Montgomery, R. E. Turner,
D. W. Phillion, E. A. Williams, B. F. Lasinski,
Kent Estabrook, and W. L. Kruer (LLNL)
and Baldis

Recent experiments were conducted on Nova in which 0.35 μm light from a single beam was incident on thin CH and Au foils. Incident intensities varied from 3 × 10^{13} to 4 × 10^{15} W/cm^2. Diagnostics were implemented to examine the temporal, spectral and angular behavior of scattered light near the incident frequency. Light scattered into the focusing lens was sampled by a 1/2-meter spectrometer equipped with a streak camera to look at time-dependent spectral behavior. Time-integrated, spectrally-resolved light was collected at various angular positions around the target and fed through optical fibers to a single 1/2-meter spectrometer using a two-dimensional detector array to record the signals. The relative intensities of the scattered light obtained in this manner can be compared to filtered photodiode signals distributed around the target. Scattered signals as a function of target material and laser intensity will be examined, as well as comparison of CH foil data with different angles between the incident laser and the target normal.

J3

Stimulated Brillouin Scattering from KrF Laser-Produced Plasma

R. Fedosejevs, J. Santiago, P. D. Gupta, R. Popil and
A. A. Offenberger (University of Alberta)

An experimental study is presently being carried out to measure the level and characteristics of stimulated Brillouin backscatter from KrF laser-produced plasmas. An f/3 18cm focal length lens is used to focus optically compressed KrF laser pulses of ~1.5ns duration onto targets of various Z giving focal spot intensities of 10^{13} to 10^{14} W/cm^2. Detailed measurements of SBS reflectivity, spectral shifts and widths, temporal correlation with the incident laser pulse and specular reflectivity have been carried out as a function of focal position and angle of incidence. The present results obtained at very low prepulse levels will be compared with earlier results obtained in the presence of a preformed plasma. Experimental results will be presented and comparisons made with the predictions of the convective growth model and the double SBS model for the generation of SBS.

*permanent address: Bhabha Atomic Research Centre, Bombay India

J4

Modulation Instability in the Beat Wave Experiments

D. Pesme (Ecole Polytechnique-Palaiseau), S. Karttunen
(Tech. Research Centre of Finland), G. Laval, N. Sylvestre,
and R. Salomaa (Helsinki Univ. of Technology)

The coupling of a plasma wave to the ion acoustic waves may result in a decay or a modulational instability. This problem is investigated in the context of beat wave experiments. An upper limit for the lasers pulse length is given, above which the plasma wave becomes incoherent before reaching the maximum amplitude allowed by the nonlinear relativistic frequency shift.

Pic-Code Studies of Beat Wave Saturation

G. Bonnaud (CEL-V), D. Pesme (Ecole Polytechnique-Palaiseau),
J. P. Matte (INRS-Energie)

Several PIC-code simulations have been performed to study beat-wave excitation with two laser beams. The parameters were: $\frac{\omega_p}{\omega_o} = 0.1$, $I\lambda^2 = 10^{16}$ W/cm^2 - m^2 in each wavelength, Te = 1 keV. In a first series of runs, $\Delta\omega$ was constant in time and $\frac{\Delta\omega}{\omega_p}$ was (a) 1, (b) 0.985 and (c) 0.96. On the basis of relativistic saturation theory,[1,2] the plasma wave should saturate at values of v_{osc}/c of (a) 0.34, (b) 0.54, and (c) 0.13. The simulations agree with theory for cases (b) and (c), but in case (a), the wave saturates at the considerably higher value of 0.49. Plasma heating is a possible explanation.

To increase the saturation amplitude one may either increase the plasma density in time[3] to compensate the ralativistic frequency shift, or diminish $\Delta\omega$ in time. Results will be presented with time varying $\Delta\omega$.

[1] M. N. Rosenbluth and C. S. Liu, Phys. Rev. Lett. 29, 701 (1972).

[2] C. M. Tang, P. Sprangle, and R. N. Sudan, Phys. Fluids 28, 1974 (1985).

[3] J. P. Matte et al., to be published in IEEE Trans. on Plasma Science.

J6

Absorption in Short Pulse Nd Laser-Produced Plasmas

Ranko
R. Dragila, B. Luther-Davies, and
A. Perry (Australian National University) Canberra

We have made extensive measurement of the absoprtion of 1μm picosecond pulse Nd laser radiation by plasmas created on planar infinite glass targets and thin ~~carbon~~ foils and obtained results that show that a mechanism other than resonance absorption dominates. Data was obtained using box calorimetry, ion calorimetry, ion probes, 2ω calorimetry, and K-alfa measurements using planar or angled targets irradiated using 20 or 100psec duration pulses focussed with F=1 optics to intensities above 10^{13}W/cm^2. We found that by scanning the position of the target through the focal plane of the focussing lens that the dominant absorption process switched off when the laser radiation diverged towards the plasma (target behind the focal plane). At the same time as the absorption dropped, the 2ω emssion peaked suggesting that resonance absorption reached a maximum: as would be expected because most of the energy in the heating pulse struck the target at non-normal incidence. Interpretation of these results with the aid of simple 2-D rigid plasma model suggested that the only explanation for this behaviour could be that absorption is dominated by an anomalous process operating only at densities close to critical and not by resonance absorption as is normally assumed. Enhanced localised collisional absorption due to ion turbulence seems to best fit the data. This interpretation is supported by absorption measurements on thin, burnt–through carbon foils.

J7

Absorption of fs Laser Pulses in Solid Targets and Plasma Formation

~~P~~ Peter Mulser
(Technische Hochschule Darmstadt)

A 1 J laser pulse of 100 fs duration is capable of creating a plasma layer from a high-Z target of 0.5 μm thickness and 1 keV temperature if the energy is transmitted to the solid. For this to happen, the standard theory of inverse bremsstrahlung absorption would require a collision frequency as high as 10^{17}. Since the actual value in the solid is a 100 times less, nearly total reflection would be the consequence. However, at high laser fields the standard expression for the current induced is no longer valid. A mechanism is proposed which leads to such phase shifts in the current that the classical cutoff at the N equal to the critical density is removed. The effect is also relevant for ps laser pulse absorption.

Laser Induced Anisotropies in Ion Acoustic Waves

J. E. Bernard, H. A. Baldis, D. M. Villeneuve (NRC-Canada),
and
A. B. Langdon (LLNL)

Theory suggests that the frequency and damping of ion acoustic waves change in the presence of a high intensity electromagnetic wave. Such effects are related to the off-resonance parametric decay and oscillating two-stream instabilities. We have used large angle, time resolved Thomson scattering to study thermal ion acoustic waves in the presence of a high intensity CO_2 laser beam. The ratio of the peak electron quiver velocity to the electron thermal velocity (v_{osc}/v_e) ranged up to 7 for focussed intensities of up to 2×10^{14} W/cm^2. The Thomson scattering optics were arranged so as to collect, in a single shot, light scattered from large k-vector fluctuations ($k > 30k_{pump}$) which propagated both parallel and perpendicular to the pump electric field (parallel and perpendicular to the electron quiver velocity). The observed frequency ratio for ion acoustic waves which propagated parallel and perpendicular to $\mathbf{v}_{osc}$ ranged up to 1.6 and was observed to increase with the ratio v_{osc}/v_e. Non-isotropic enhancements in the fluctuation levels were also observed as predicted by theory. The results of these measurements will be presented and compared to theoretical predictions.

J9

Consequences of Deformed Electron Velocity Distributions in the Corona

Jean-Pierre Matte (INRS-Energie),
J. F. Luciani, M. Bendib (Ecole Polytechnique-Palaiseau),
and T. W. Johnston (INRS-Energie)

Three physical mechanisms make the electron velocity distribution deviate strongly from an isotropic Maxwellian in the underdense plasma. 1) Heat flow: as electrons with large $|V_x|$ stream from the hot corona towards the colder overdense plasma, the velocity distribution is flattened; 2) Expansion: this also tends to flatten the velocity distribution as cooling is in the direction of the gradients; 3) Inverse Bremsstrahlung absorption, which makes the isotropic part of f super-gaussian (exp $(-v^m/w^m)$ with $2 < m < 5$). Analysing the underdense distribution functions from our Fokker-Planck simulations(1), we find that the anisotropy is strong ($f_2/f_0 \sim -1$) for $v/v_{te} > 3$, where f_0 is the isotropic part and f_2 is the second order Legendre polynomial component. The m value was found to be 2.8 for the parameters studied ($\lambda = 1.064$, $I = 3 \times 10^{14}$ W/cm^2, $Z = 4$). Runs were also made with blue light ($\lambda = 0.35$ μm). The anisotropy is shown to drive a Weibel type instability, with a growth rate of order 10^{11} sec^{-1} and a large convective growth ($> 10^4$). The growth of this mode is far larger than the much-studied Weibel instability which exists due to positive f_2 in the overdense plasma. Another consequence of the deformation is that $F(V_x)$, the one dimensional distribution function, falls off more rapidly with V_x and, therefore, strong Landau damping occurs for larger values of $k\lambda_D$ than it would for an isotropic Maxwellian. Therefore, the temperature diagnostic which is based on the low-frequency cutoff of Raman backscatter ($k\lambda_D = 0.25$ or 0.3 for a Maxwellian) appears to underestimate the actual plasma temperature.

[1] J.P. Matte, T.W. Johnston, J. Delettrez and R.L. McCrory, Phys. Rev. Lett. 53, 1461 (1984).

Target Charging in Evacuated Target Chambers

A. Bruce Langdon (LLNL)

Some have feared that targets driven by beams of heavy ions would charge up so much during the pulse as to be able to repel or deflect the beam later in the pulse. Darwin Ho et al have studied target discharge in chambers containing gas that becomes photoionized. I show that, even in vacuum, target charging is limited, by electrostatic expulsion of target ions to large radii, to ~ 50 MV -much less than the beam energy.

As the target is charged by the beam, it expels its own ions so as to keep itself nearly neutral. To the extent that these ions are accelerated far from the target, the target potential is reduced.

To analyze the transient, space-charge-limited discharge of the target, I adapt a Lagrangian method used for AC analysis of diodes.[1] The solution of a model problem can be obtained with paper and a calculator. As a numerical example, take I_i = 30 kA, T = 20 ns, r_t = 1 cm, and assume the expelled target ions are protons (a few nanograms of hydrogen is enough). We find that the ion cloud extends to 137 cm, and the final target potential is only 35 MV in this model, compared to several GeV for the beam.

ZOHAR simulations, that only assume spherical symmetry, supplement the analytic results.

Target charging does not appear to be one of heavy ion fusion's problems.

1. *Electron Dynamics of Diode Regions*, C. K. Birdsall and W. B. Bridges, Academic Press, 1966.

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.

J11

Measurements of Anomalous Thermal Electron Heating and Heat Transport

K. Mizuno and J. S. DeGroot (University of California-Davis)
and Wolf Seka

We present a new mechanism of anomalous thermal electron heating and heat transport inhibition. The thermal electron heating and transport inhibition is due to scattering by ion turbulence. The ion acoustic turbulence is excited by the ion acoustic decay instability. This mechanism is important when a moderate power laser ($10^4 \sim 10^{15}$ W/cm^2 for blue light) irradiates a large scale length plasma. We have used microwave simulation experiments to study anomalous electron heating and heat transport due to ion wave turbulence in a long underdense plasma ($n = 0.6 \sim 0.8\ n_c$). The parametric decay instability can be excited in the microwave (or laser) power regime $I\lambda^2/T_e$ (W/cm^2)(μm)^2/(keV) < or ~ 5×10^{14} in a self-consistently modified underdense plasma. The parametric instability excites strong <u>isotropic</u> ion wave turbulence.[1] The instability also heats warm ($T_w \sim 4\ T_t$) electrons[2], which are transported toward the high density region. Then, a return current is induced to maintain charge neutrality. A drifted electron distribution function is clearly observed in the overdense region. The drifting electrons are scattered by the isotropic ion wave turbulence, and, therefore, the thermal electrons are heated (anomalous Joule heating). The thermal electron heat flow is inhibited due to the ion wave resistivity. Our results agree fairly well with simple theoretical calculations.

1. K. Mizuno, F. Kehl, and J. S. De Groot, Phys. Rev. Lett. 56, 2184 (1986).
2. K. Mizuno, J. S. De Groot, and K. G. Estabrook, Phys. Rev. Lett. 52, 271 (1984).

* Work supported by Lawrence Livermore National Laboratory.

Session K

(Review)

The Role of Nonlinear Effects in RF Heating and Current Drive in Magnetic Fusion

Miklos Porkolab (MIT)

Thursday, 8:00 PM

Chairman: W. L. Kruer (LLNL)

The Role of Nonlinear Effects in RF Heating and Current Drive in Magnetic Fusion

Miklos Porkolab (MIT)

Nonlinear effects play an important role in RF heating and current drive experiments in magnetically confined fusion plasmas. Several examples of nonlinear phenomena which have been observed in recent experiments will be described. Of particular importance is selective quasi-linear deformation of the electron distribution function, leading to current drive and electron heating. Such phenomena have been studied extensively in recent lower hybrid wave launching experiments in tokamaks. A different class of nonlinear interactions include parametric instabilities which play a crucial role in preventing lower hybrid waves from penetrating to the plasma interior for $\omega \sim \omega_{LH}$, when ion heating is desired in tokamaks [ω_{LH} is the lower hybrid frequency]. Parametric instabilities have also been observed in electron cyclotron wave heating experiments [ECRH] when incomplete single pass absorption allows wave penetration to the upper hybrid layer. Very recently in ion Bernstein wave heating experiments [IBW] in tokamaks efficient plasma heating has been discovered at frequencies $\omega = (m + 0.5)\ \omega_{ci}$ where m = 1,2, . . . is an integer, and ω_{ci} is the ion cyclotron frequency (majority, or even minority species). This phenomenon has been explained recently as being a result of nonlinear ion cyclotron (Landau) damping of the short wavelength beat wave. Significant particle, and possibly energy confinement improvement is observed simultaneously. Another important class of nonlinear phenomena include the modification of density profiles, and possible stabilization of MHD modes by the strong ponderomotive force exerted in ICRH (ion cyclotron resonance heating) and LHH (lower hybrid heating) experiments, especially in the near field zone close to the antenna. Finally, recent advances in the development of FEL's (free electron laser) offer the potential for delivering ultra high frequency radiation ($f = 300 - 600$ GHz) to tokamak plasmas, allowing ECR and harmonic heating and current drive in the reactor regime. Due to the high peak power ($P \lesssim 10$ GW, $E_{RF} \lesssim 0.5$ MeV/cm) and pulsed form of radiation nonlinear dynamics is expected to dominate all aspects of the wave absorption. Intensive theoretical efforts are underway to predict the expected wave penetration and absorption. Some of the expected phenomena will be discussed. A test of the theoretical predictions will be carried out in the proposed MTX experiment at LLNL.

Session L

(Oral)

X-Rays: Conversion, Lasers

Friday, 9:00 AM

Chairman: J. A. Cobble (LANL)

L1

Effects of ISI on the Interaction of 1.05μm Light with High-Z Plasmas

D. R. Kania and P. Bell (LLNL), S. P. Obenschain,
K. J. Kearney, C. K. Manka, A. N. Mostorichi, and J. Grun (NRL)

The Pharos III was used to irradiate Au targets with 1.06 μm light. The laser was operated in a variety of conditions using a broad band or narrow band oscillator with and without echelons. Operation with the broad band oscillator and echelons produces highly uniform intensity distribution, this is called induced spatial incoherence or ISI.[1] For all operating conditions, the incident laser energy was approximately 300 J in a 2 ns pulse at an irradiance of 10^{14} W/cm^2. We studied the effects of ISI relative to other laser operating conditions. The production of low energy x-radiation (E < 1 keV) was recorded on two photoconductive x-ray detectors.[2] Laser light absorption was monitored by measuring SBS light on each shot at a variety of positions in the backscattered direction. We will discuss the systematic differences between ISI and non-ISI interactions on the production of low energy x-rays.

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

[1] S.P. Obenschain, et al., Phys. Rev. Lett. <u>56</u>, 2807 (1986).
[2] D.R. Kania, et al., J. Appl. Phys. <u>60</u>, 2596 (1986).

Advances in Time-Resolved Measurements of X-ray Conversion Efficiencies

F. Ze, H. Kornblum, B. Lasinski, R. Thiessen, R. Kauffman, P. Drake, S. Langer,
D. Montgomery, L. Sutter, and G. Tietbohl (LLNL)

To date the best known approach in obtaining x-ray conversion efficiencies from laser irradiated targets has been the use of absolutely calibrated, ~ 200 ps resolution, multichannel photodiode systems.

Recently, we took another step to improve our understanding of laser-plasma interaction physics by doing similar soft x-ray spectral measurements with a 50 ps resolution diagnostic system. The goal was to obtain a better comparison between the data and physics modeling. The diagnostics we used consisted of mirror-filter pairs coupled to a streak camera. The channel configuration was made to coincide with six of the ten channels used in the Dante system and has a spectral coverage extending from approximately 200 to 1300 eV photon energy. Cross-normalization with the Dante allowed the instrument to obtain x-ray yields in absolute units. This technique has enabled us not only to temporally track changes in x-ray spectra, but also to obtain time-histories of x-ray conversion efficiencies. Results from planar target experiments recently done at Nova with single and picket-fence laser pulses, will be shown.

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

Gold Disc Irradiations at 3 ω

B. F. Lasinski, F. Ze, R. L. Kauffman, A. R. Thiessen,
H. N. Kornblum, and R. P. Drake (LLNL)

We discuss the LASNEX modeling of Nova 3ω, gold disc irradiations for a variety of laser intensities and temporal pulse shapes. At this short wavelength, the measured absorption fraction is high, ~90%. Our emphasis is on the energy budget in these gold disc irradiations. The 1-D and 2-D simulation results are compared to both time integrated and time resolved diagnostics of x-ray emission. The effect of the size of the incident laser spot is also studied.

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

L4

Experiments with Laser-Heated Cavities

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The conversion of the laser energy into soft x-rays and its thermalization and confinement inside a closed geometry target has been investigated experimentally and theoretically. Using the ASTERIX-III laser system spherical gold cavities (0.3 - 1.0 mm in diameter) were heated with an average intensity of 10^{12} to $3 \cdot 10^{13} W/cm^2$. A systematic study has been performed at two different wavelentghs of $\lambda = 1.3 \mu m (1\omega)$ and $\lambda = 0.44 \mu m (3\omega)$. Various diagnostics provide information about the laser light absorption, the dynamic behavior of the expanding shell and the temperature variation of the inner cavity wall. Particular emphasis has been given to the study of the spectra emanating from the interior of the cavity. The experimental results are compared with the predictions of a model based on the diffusive loss of radiation into the cavity wall and found in good agreement. In addition, the post-processing atomic physics code HOLRAD reproduces the main features of the experimentally obtained spectra. The heating experiments showed that more favorable conditions can be achieved at $\lambda = 0.44 \mu m$ and effects like plasma filling and hole closure can be avoided. A brightness temperature of 192 eV has been recently achieved in a joint experiment with ILE/Osaka using more energetic laser pulses[1]. It is concluded that the laser-plasma interaction processes at high intensity may pose a limitation for generating intense thermal radiation in a cavity.

1. T. Mochizuki et al. IAEA Conference on Plasma Physics and Controlled Nuclear Fusion Research, Kyoto, Japan, 13-20 Nov. 1986, Paper IAEA-CN-47/B-I-3

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Design and Optimization of Recombination X-Ray Lasers

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X-ray laser experiments employing the recombination mechanism in rapidly cooling exploding foils are simulated in order to model the amplification of carbon line emission observed in experiments on the OMEGA laser system with carbon/selenium foils,[1] to optimize possible future experiments, and to evaluate the utility of devices such as radiational cooling in optimizing the inversion of excited-state populations of highly-ionized species. Some attention is given to recent claims that radiational cooling is crucial to optimizing the carbon/selenium experiment.[2] The simulations are based on the one-dimensional hydrocode LILAC running with average-ion atomic physics and a radiative-transfer post-processor using a detailed-configuration model of the level populations of the most highly ionized species.

a) Visiting scientist on leave from Nuclear Research Center Negev, Israel.

[1] J. F. Seely, C. M. Brown, U. Feldman, M. Richardson, B. Yaakobi, and W. E. Behring, Opt. Commun. **54**, 289 (1985).

[2] C. H. Nam, E. Valeo, S. Suckewer, and U. Feldman, J. Opt. Soc. Am. B **3**, 1199 (1986).

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Beam Optics of Laboratory X-ray Lasers

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In an optically driven soft x-ray laser, electron density gradients can refract the x-rays as they propagate down the long narrow plasma column. The exploding foil design lessens the refraction, thereby lengthening the beam's travel within the lasing medium (Rosen et al 1985). In this paper we present a quantitative analysis of the propagation and amplification of the x-rays, using an approximate description of the exploding foil, in which the perpendicular electron density profile is taken to be parabolic.

The calculated angular beam pattern is dominated by a peak on the x-ray laser axis. The angular width of the peak is determined by the central electron density, the parabolic scale-length, the x-ray laser wavelength and the laser gain coefficient. It is found that refraction introduces a loss term to the laser amplification for large gain-lengths. We compare results for the beam pattern to experimental data from selenium x-ray lasers.

The approach to saturation with laser length is also examined. We find that refraction increases the saturation length, but does not effect the saturation power.

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Studies of High-Density-Plasma Waveguides for X-ray Lasers

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The conventional exploding foil approach to x-ray laser suffers from both the refraction of the x-rays out of the lasing region, resulting in a limited effective lasing length, and the lower density which is a consequence of the need of a large lateral dimension needed to reduce refraction effects.

We investigate new types of geometries, in which the plasma is hydrodynamically confined, and therefore: (a) it is at a higher density, leading to higher gain, (b) it exhibits a concave density profile which can serve as a waveguide for the x-rays and increase their effective gain path.

Various theoretical and practical considerations of those new geometries will be presented and discussed.

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Experimental Study of Single and Double Foils for X-ray Laser Media

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We present results of experiments in which targets were irradiated by a line focus of 527-nm laser light at intensities of 10^{13}-10^{14} W/cm^2. We investigate exploding thin foils (300-800 Å Ni) and various combinations of double foils using thin and massive Ni targets separated by 150-300 μm. The double-target configurations provide extended plasmas as a result of the collision of explosive and/or ablative laser plasmas. Time-resolved measurements of the light transmitted through single foils of various thickness are used to study the burnthrough of these targets. Pinhole images and spatially resolved x-ray spectra in the range 0.6-1.5 keV are used to diagnose the radial expansion of these plasmas transverse to the line focus. Compared with a single exploding foil, the double targets produce plasmas with longer scalelengths and similar or greater densities. We present an analysis of these experiments and a comparison with 1-D and 2-D hydrocode simulations. We examine the a dependence of the relative population of Ne-like atoms on laser and target parameters and discuss the relevance of these results to x-ray-laser target designs.

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Energy Partitioning of Spherically Irradiated Targets

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Radiated energy, electron energy, and mass flow have been measured from spherical targets as a function of incident laser intensity. Solid CH and glass spherical targets were irradiated with 24 beams from the OMEGA laser. Laser intensities were varried from 10^{13} W/cm^2 to 10^{16} W/cm^2. All of the energy measurements are time integrated and are compared to the absorbed energy as measured by 15 plasma calorimeters. Au coated spheres were irradiated and the ratio of radiation energy to absorbed energy was compared to previous measurements done with the OMEGA laser.

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S. Witkowski	
B. Yaakobi	C3, D3, L5, L7, L8
C. Yamanaka	D8, I10
Y. T. Yan	I9
B. K. Young	I2
P. E. Young	J2
F. Ze	L2, L3

REVISIONS TO THE TECHNICAL AGENDA

New Number	Old Number	Title and Author
Withdrawn	C1	Self-Similar Cooling of Ablative Heat Waves by Non-linear Heat Diffusion, R. Pakula (Lehigh Univ.)
C1	L1	Effects of ISI on the Interaction of 1.05 m Light with High-Z Plasmas, D. R. Kania and P. Bell (LLNL), S. P. Obenschain, K. J. Kearney, C. K. Manka, A. N. Mostorichi, J. Grun (NRL)

The first five talks in Session D have been reordered. They report implosion experiments by LLE using OMEGA.

New Number	Old Number	Title and Author
D1	D5	
D2	D1	
D3	D3	
D4	D4	
D5	D2	
Withdrawn	F3	Superathermal Electron Production in a Magnetized Plasma, C. Domier and N. C. Luhmann, Jr. (UCLA)
Withdrawn	F10	Role of Langmuir Wave Non-Linearities in Simulated Raman Scattering (SRS), G. Bonnaud (CEL-V), and D. Pesme (Ecole Polytechnique-Palaiseau)
F11	J5	Pic-Code Studies of Beat Wave Saturation, G. Bonnaud (CEL-V), J. P. Matte (INRS-Energie)
F12		Enhancement of Long-Scale Magnetic Fields in Spatially Random-Phased Laser Illumination of a CH Foil, Y. Kitagawa, T. Yube, Y. Kato, C. Yamanaka (Osaka)
G11		The Dynamical Regimes of Low-Threshold Nonlinear Scattering in Inhomogeneous Plasmas, V. T. Tikhonchuk (Lebedev Physical Institute)

New Number	Old Number	Title and Author
I11	A2	High Energy Electrons in Laser Target Interactions, F. Amiranoff, C. Labaune, C. Rousseaux, B. Mabille (Ecole Polytechnique-Palaiseau), and G. Matthieussent (Laboratoire de Physique des Gas et des Plasma-ORSAY)
I12		Simulation of Laser-Plasma Interactions with Atomic and Radiation Effects, R. Marchand, C. E. Capjack, R. Fedosejevs (Univ. of Alberta), and Y. T. Lee (LLNL)
I13		The Role of Langmuir Cavitons in Ionospheric Modification Experiments at Arecibo, M. P. Sulzer, H. M. Ierkic, and J. A. Fejer
J5		Spontaneous Magnetic-Field Registration in the Laser Plasma on Delphin-1, E. G. Gamalay (Lebedev Physical Institute)