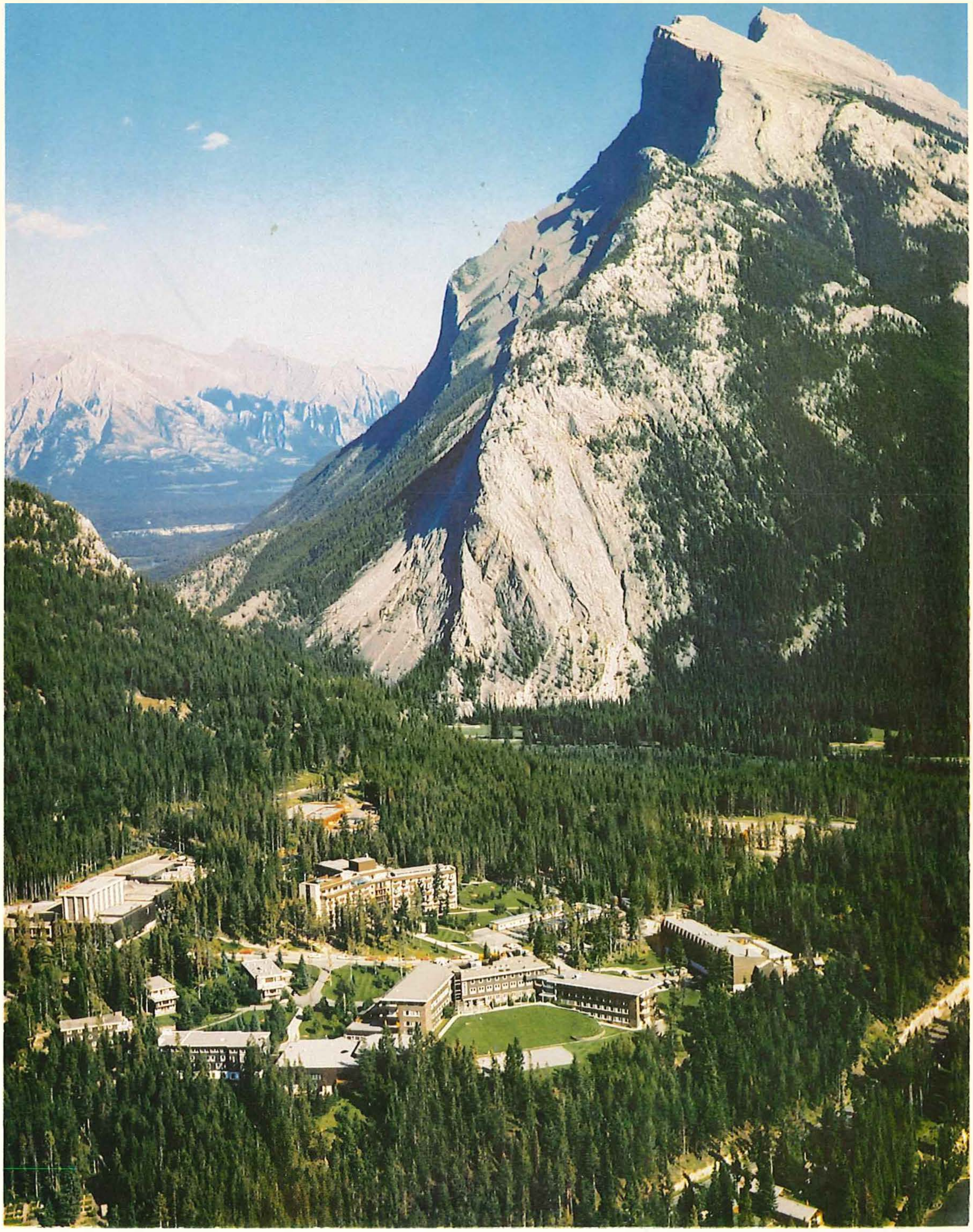

13th ANNUAL

ANOMALOUS ABSORPTION CONFERENCE

JUNE 5-10, 1983

THE BANFF CENTRE, BANFF, ALBERTA

Organized by: Laser-Plasma Research Laboratory
University of Alberta
Edmonton, Alberta, Canada

13th Annual

ANOMALOUS ABSORPTION CONFERENCE

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The Banff Centre, Banff, Alberta
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SESSION SCHEDULE

A. PARAMETRIC INTERACTIONS (oral), June 6, 8:30 a.m.-12:15 p.m.
Chairman: N.C. Luhmann, Jr., UCLA

B. INVITED REVIEW ON STRONG TURBULENCE, June 6, 6:30 p.m.-8:00 p.m.
R. Pellat, Ecole Polytechnique
Discussion Leader: W.M. Manheimer, NRL

C. PARAMETRIC INTERACTIONS (poster), June 6, 8:00 p.m.-11:00 p.m.

D. PARAMETRIC INTERACTIONS, HOT ELECTRONS, FAST IONS (oral), June 7, 8:30 a.m.-11:45 a.m.
Chairman: R. Fedosejevs, University of Alberta

E. INVITED REVIEW ON NON-MAXWELLIAN DISTRIBUTION FUNCTIONS, June 7, 6:30 p.m.-8:00 p.m.
W. Kruer, LLNL
Discussion Leader: A.B. Langdon, LLNL

F. PARAMETRIC INTERACTIONS, HOT ELECTRONS, FAST IONS (poster), June 7, 8:00 p.m. - 11:00 p.m.

G. ABSORPTION, TRANSPORT (oral), June 8, 8:30 a.m.-12:15 p.m.
Chairman: R.J. Mason, LANL

H. INVITED REVIEW ON ELECTRON THERMAL TRANSPORT, June 8, 6:30 p.m.-8:00 p.m.
T.J.M. Boyd, Univ. of Wales
Discussion Leader: T.W. Johnston, INRS-Energie

I. ABSORPTION, TRANSPORT (poster), June 8, 8:00 p.m.-11:00 p.m.

J. HYDRODYNAMICS (oral), June 9, 8:30 a.m.-12:15 p.m.
Chairman: M.C. Richardson, LLE

K. INVITED REVIEW ON RADIATIVE TRANSPORT, June 9, 6:30 p.m.-8:00 p.m.
K. Whitney, NRL
Discussion Leader: D. Attwood, LLNL

L. HYDRODYNAMICS (poster), June 9, 8:00 p.m.-11:00 p.m.

M. SHORT WAVELENGTH, LONG SCALELENGTH, TARGETS (oral), June 10, 8:30 a.m.-10:45 a.m.
Chairman: R.R. Johnson, KMS Fusion

N. FINAL DISCUSSION and NEXT YEAR'S MEETING, June 10, 11:00 a.m.-12:30 p.m.
A.A. Offenberger, Univ. of Alberta

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CONFERENCE TIME TABLE

SUNDAY, June 5 2:00 - 8:00 p.m.	Registration
8:00 p.m.	Cocktail Party

MONDAY, June 6

Session A PARAMETRIC INTERACTIONS (oral),
Chairman: N.C. Luhmann, Jr., UCLA

8:30 a.m. - 8:45 a.m.		Introductory Remarks, A.A. Offenberger (Univ. of Alberta)
8:45 a.m. - 9:00 a.m.	A1	"Saturation and Harmonics of the Ion Wave in SBS", C.E. Clayton, C. Joshi, F.F. Chen (UCLA)
9:00 a.m. - 9:15 a.m.	A2	"Temporally and Spectrally Resolved Backscatter Measurements at 10.6 μm", H.A. Baldis, C.J. Walsh (NRC)
9:15 a.m. - 9:30 a.m.	A3	"Ion Trapping and Heating in Stimulated Brillouin Scattering", R. Giles, A.A. Offenberger (Univ. of Alberta)
9:30 a.m. - 9:45 a.m.	A4	"Absolutely Unstable Stimulated Brillouin Scattering in Inhomogenous Plasma", R.L. Berger (KMSF)
9:45 a.m. - 10:00 a.m.	A5	"Efficient Way to Prevent Reflection from Stimulated Brillouin Backscattering", C. Montes (GRECO-C.N.R.S.)
10:00 a.m.- 10:15 a.m.	A6	"Absolute Instability Criterion for Parametric Decay Wave Processes with Nonuniform Coupling", T.W. Johnston, G. Picard (INRS)
10:15 a.m.- 10:30 a.m.	A7	"Langmuir Waves in Periodic Structure", T. Speziale (KMSF)
10:30 a.m.- 11:00 a.m.		COFFEE BREAK
11:00 a.m.- 11:15 a.m.	~~A8~~ → D2	"The Convective Raman Instability", E.A. Williams, R. Short (LLE)
11:15 a.m.- 11:30 a.m.	A9	"Kinetic Model for Plasmas in the Underdense Region", W. Rozmus, Y. Al-Shiraida, A.A. Offenberger (Univ. of Alberta).
11:30 a.m.- 11:45 a.m.	~~A10~~ A8	"Half Integer Harmonic Radiation from Laser Plasmas", W. Seka, L.M. Goldman, M.C. Richardson, K. Tanaka, R. Short, E.A. Williams (LLE)
11:45 a.m.- 12:00 p.m.	A11	"3/2 ω_o Emission from Underdense Plasmas", D.M. Villeneuve, H.A. Baldis, C.J. Walsh (NRC)
12:00 p.m.- 12:15 p.m.	A12	"Spectroscopic Study of Second Harmonic Emission from Spherically Irradiated Plasmas with λ_L = 1.054 μm", K. Tanaka, L.M. Goldman, M.C. Richardson, W. Seka, J. Soures, R. Short, E.A. Williams (LLE)

Session B

6:30 p.m. - 7:30 p.m. INVITED REVIEW ON STRONG TURBULENCE, R. Pellat, Ecole Polytechnique

7:30 p.m. - 8:00 p.m. Discussion, Discussion Leader: W.M. Manheimer (NRL).

Session C

8:00 p.m. - 11:00 p.m. PARAMETRIC INTERACTIONS (poster)

C1 "Millimeter Wave Scattering Measurement of the Growth and Saturation of Ion Waves in a Microwave-Plasma Interaction Experiment", C. Pawley, N.C. Luhmann, Jr.(UCLA)

C2 "Stimulated Scattering of a Strong KrF Pump in a Plasma Waveguide", R. Marchand, C. E. Capjack, C. R. James (Univ. of Alberta).

C3 "Ion Turbulence in Laser Plasma Interactions", Y.S. Al-Shiraida, W. Rozmus, A.A. Offenberger (Univ. of Alberta), A. Ng (Univ. of British Columbia)

C4 "Optical Mixing and SRS in a θ-Pinch Plasma", B. Amini, F.F. Chen (UCLA)

C5 "1½ D Simulation of Raman Scattering", A. Alfheim, A.J. Barnard, E. Hiob (Univ. of British Columbia)

C6 "Experimental Studies of SBS", H.A. Baldis, C.J. Walsh (NRC)

C7 "Filamentation of Light with a Diffuse Angular Spread", A.B. Langdon (LLNL).

C8 "Temporal and Spectral Behaviour of Stimulated Backscatter in a CO_2 Laser-Gas Jet Experiment", J.E. Bernard, J. Meyer, H. Houtman, B. Hilko, G. McIntosh, and R. Popil (Univ. of British Columbia)

C9 "Observations of Hot Electron Spectra Produced by Stimulated Raman Scattering", R.G. Berger, R.D. Brooks, Z.A. Pietrzyk (Univ. of Washington)

C10 "Hot Electron Generation from Plasma Wave Damping in the Presence of a Magnetic Field", W. Mori, C. Joshi, F.F. Chen, J.M. Dawson, R. Huff (UCLA)

C11 "Evolution from Coherence to Turbulence in Plasmas", A.Y. Wong, P. Cheung, T. Tanikawa (UCLA)

C12 "Trapping of Plasma Waves in Cavitons", T. Tanikawa, A.Y. Wong and D. Eggleston (UCLA)

TUESDAY, June 7

Session D -- PARAMETRIC INTERACTIONS, HOT ELECTRONS, FAST IONS (oral), Chairman: R. Fedosejevs, Univ. of Alberta

8:30 a.m.- 8:45 a.m.	D1	"On the Inhomogeneous Two Plasmon Instability", A. Simon, R.W. Short, E.A. Williams, T. Dewandre (LLE)
8:45 a.m.- 9:00 a.m.	~~D2~~ A10	"The Two Plasmon Instability in a Filament", R.W. Short, E.A Williams (LLE)
9:00 a.m.- 9:15 a.m.	D3	"Experimental Investigation of Energetic Electrons Produced at the Quarter Critical Density in CO$_2$- Plasma Interaction", J. Meyer, J.E. Bernard, B. Hilko, H. Houtman, G. McIntosh, R. Popil (Univ. of British Columbia)
9:15 a.m.- 9:30 a.m.	D4	"Fast Electrons from Localized Strong Travelling Waves", T.W. Johnston (INRS), V. Fuchs (IREQ)
9:30 a.m.- 9:45 a.m.	D5	"Instability Induced Hot Electrons in CO$_2$ Laser Plasmas", J.M. Kindel and D.W. Forslund (LANL)
9:45 a.m.- 10:00 a.m.	D6	"Suprathermal Electron Transport in CO$_2$ Laser Plasma", J.C. Kieffer, H. Pépin, J.P. Matte, P. Lavigne, F. Martin (INRS), R. Décoste (IREQ), A. Amiranoff (Ecole Polytechnique)
10:00 a.m.- 10:15 a.m.	D7	"Implications of Fluorescent Yield Measurements for Hot Electron Target Coupling in Planar Geometry", N.H. Burnett, G.D. Enright (NRC)
10:15 a.m.- 10:30 a.m.	D8	"Experimental Study on Pellet Implosion by High Power CO$_2$ Laser LEKKO VIII", H. Fujita, H. Daido, H. Nishimura, R. Tateyama, K. Ogura, M. Fujita, M. Inoue, K. Terai, K. Sawai, S. Nakai and C. Yamanaka (Osaka Univ.)
10:30 a.m.- 11:00 a.m.		COFFEE BREAK
11:00 a.m.- 11:15 a.m.	D9	"Ion Generation from CO$_2$ Laser Irradiated Surfaces", T. H. Tan and A. H. Williams (LANL).
11:15 a.m.- 11:30 a.m.	D10	"Fast Ion Spectra: Comparison of Model Predictions with Measurements", D. Mitrovich (WRC)
11:30 a.m.- 11:45 a.m.	D11	"The Production of Collimated Fast Ions from CO$_2$ Driver Targets", C.W. Barnes, D.W. Forslund, and G. Kyrala (LANL)

Session E

6:30 p.m.- 7:30 p.m.	INVITED REVIEW ON NON-MAXWELLIAN DISTRIBUTION FUNCTIONS, W. Kruer (LLNL)
7:30 p.m.- 8:00 p.m.	Discussion Discussion Leader: A.B. Langdon (LLNL)

Session F

8:00 p.m.- 11:00 p.m. PARAMETRIC INTERACTIONS, HOT ELECTRONS, FAST IONS (poster)

F1 "Evidence for Anomalous Transport of Fast Electrons in Spherical Geometry", J.A. Tarvin (KMSF)

F2 "Kinetic Two-Plasmon Decay in Weakly Inhomogenous Plasmas", L.V. Powers, R.L. Berger (KMSF)

F3 "The $2\omega_{pe}$ Instability in Current Experiments", B.F. Lasinski, A.B. Langdon, W.L. Kruer, W.C. Mead, R.E. Turner, E.M. Campbell, D.W. Phillion, and R.P. Drake (LLNL)

F4 "Angular Dependence of Scattered ω_o and $2\omega_o$ Radiation for CO_2 Laser Produced Plasmas", F. Martin, J. Sabbagh, H. Pépin, T.W. Johnston, P. Lavigne (INRS), G.R. Mitchel (Hydro-Québec)

F5 "Two-Dimensional Laser Generated Suprathermal Transport with Collisional Thermal Return Currents", R.J. Mason (LANL), D. Besnard (Limeil)

F6 "Spatial Distribution of Hot-Electrons in Microwave Plasma Interaction", M. Shimizu and Y. Nishida (Utsunomiya Univ.)

F7 "Dynamic Acceleration of Electrons in Microwave Plasma Interaction", M. Yoshizumi, Y. Nishida (Utsunomiya Univ.), R. Sugihara (Nagoya Univ.)

F8 "Some Mechanisms of Hot Electron Preheating Suppression in a Cavity Target", K. Mima, H. Nishimura, H. Daido, S. Nakai and C. Yamanaka (Osaka Univ.)

F9 "Measurement of the Ion Spectra from CO_2 Laser Produced Plasmas by Means of Filtered Calorimeters", J.F. Kephart, A.W. Ehler, S.J. Gitomer, A. Hauer, R. Kristal, H. Oona, T.H. Tan, A.H. Williams, and M.A. Yates (LANL)

F10 "Observation of High Energy Heavy Ion Velocity Distribution in CO_2 Laser-Created Plasmas", F. Begay, W. Ehler, A. Hauer, S.R. Goldman, and G.R. Magelssen (LANL)

F11 "Fast Ion Spectra from CO_2 Laser Produced Plasmas", S.J. Gitomer, R.D. Jones, F. Begay, A.W. Ehler and J. Kephart (LANL)

WEDNESDAY, June 8

Session G -- ABSORPTION, TRANSPORT (oral)
Chairman: R.J. Mason, LANL

8:30 a.m.- 8:45 a.m.	G1	"The Effects of Ion-Acoustic Turbulence on Short Pulse Laser Plasma Interactions", R. Dragila, M.D.J. Burgess, B. Luther-Davies, K.A. Nugent, A. Perry, G.J. Tallents (Australian National Univ.)
8:45 a.m.- 9:00 a.m.	G2	"Resonant Absorption at a Sharp Boundary", K.B. Quest and J.M. Kindel (LANL)
9:00 a.m.- 9:15 a.m.	G3	"Interaction Physics in Spherical Geometry", M.C. Richardson, J. Delettrez, L.M. Goldman, R.L. Keck, W. Seka, R. Short, J.M. Soures, K. Tanaka, and E.A. Williams (LLE)
9:15 a.m.- 9:30 a.m.	G4	"Energy Balance in a Laser Gas Jet Experiment", R. Popil, J. Meyer, J.E. Bernard, B. Hilko, H. Houtman, G. McIntosh (Univ. of British Columbia)
9:30 a.m.- 9:45 a.m.	G5	"Classical Heat Transport by Non Maxwell-Boltzmann Electron Distribution", J.R. Albritton (LLNL)
9:45 a.m.- 10:00 a.m.	G6	"Fluid Modeling of Magnetically Enhanced, Lateral Transport", J.U. Brackbill (LANL)
10:00 a.m.- 10:15 a.m.	G7	"Interpretation of Recent Thermal and Suprathermal Transport Experiments", W.B. Fechner and J.T. Larsen (KMSF)
10:15 a.m.- 10:30 a.m.	G8	"Analysis of Thermal Transport Experiments and their Implication of a Threshold for Transport Inhibition", M.D. Rosen (LLNL)
10:30 a.m.- 11:00 a.m.		COFFEE BREAK
11:00 a.m.- 11:15 a.m.	G9	"The Effect of Thermal Flux Saturation on Lateral Heat Transport - A Multi-Group Analysis", S. Skupsky, J. Delettrez (LLE)
11:15 a.m.- 11:30 a.m.	G10	"Simulation of Transport Experiments at LLE Using Non-Local Electron Transport Models",J. Delettrez, S. Skupsky (LLE) D. Shvarts (NRC, Negev), R. L. McCrory (LLE)
11:30 a.m.- 11:45 a.m.	G11	"Spectral Signatures of Non-Maxwellian and Non-LTE Effects in Thermal Transport Experiments", R. Epstein, S. Skupsky and B. Yaakobi (LLE)
11:45 a.m.- 12:00 p.m.	G12	"Heat Flux Limitation due to Hot Electrons", I.P. Shkarofsky (MPB Technologies)
12:00 p.m.- 12:15 p.m.	G13	"Solution of the Time-Independent Vlasov-Fokker-Planck Equation for a Planar Ablating Plasma", A.R. Bell (Rutherford)

Session H

6:30 p.m.- 7:30 p.m.		INVITED REVIEW ON ELECTRON THERMAL TRANSPORT, T.J.M. Boyd, Univ. of Wales
7:30 p.m.- 8:00 p.m.		Discussion Discussion Leader: T.W. Johnston, INRS-Energie

Session I

8:00 p.m.- 11:00 p.m.		ABSORPTION, TRANSPORT (poster)
	I1	"On the Use of X-Ray Radiation to Diagnose Laser Plasmas by Refractrometry", R. Benattar (Ecole Polytechnique)
	I2	"Time-Dependent X-ray Spectra From Laser-Produced Plasmas", R. L. Kauffman, D. L. Matthews, R. W. Lee, and B. Whitten (LLNL)
	I3	"Multi-Photon Ionization in Laser-Plasma Simulations", J.W. McMullin, C.E. Capjack (Univ. of Alberta)
	I4	"A Conservative Electron Fokker-Planck (Landau) Code", A. Decoster (Limeil)
	I5	"Flux Limited Transport Coefficients in Plasmas with Steep Gradients", P.M. Campbell, J.T. Larsen (KMSF)
	I6	"Electron Heat Flow with Inverse Bremsstrahlung and Hydro Motion", J.P. Matte, T.W. Johnston (INRS), J. Delettrez, R.L. McCrory (LLE), J. Virmont (Ecole Polytechnique)
	I7	"Collisional Aspects of Suprathermal Transport in CO_2 Laser Target Interactions", S.R. Goldman, J.U. Brackbill, D.W. Forslund, A.A. Hauer, R. Mason, and M. Mueller (LANL)

THURSDAY, June 9

Session J -- HYDRODYNAMICS (oral)

Chairman: M.C. Richardson (LLE)

8:30 a.m.- 8:45 a.m.	J1	"Directions of NRL Research", S.E. Bodner, D. Colombant, M.H. Emery, J.H. Gardner, J. Grun, M.J. Herbst, S. Kacenjar, K. Kim, R.H. Lehmberg, W. Manheimer, E.A. McLean, S.P. Obenschain, B.H. Ripin, J.A. Stamper, R.R. Whitlock and F.C. Young (NRL)
8:45 a.m.- 9:00 p.m.	J2	"Broad-Band Laser-Target Interaction", S.P. Obenschain, J. Grun, M.J. Herbst, K. Kearney, E.A. McLean, N.E. Nocerino, J.A. Stamper, R.R. Whitlock, F.C. Young, S.E. Bodner, S. Kacenjar, K. Kim, J. Kosakowski, R.H. Lehmberg and B.H. Ripin (NRL)

9:00 a.m.- 9:15 a.m.	J3	"Improvement of Irradiation Uniformity by Random Phase Mask", K. Mima, Y. Kato and C. Yamanaka (Osaka Univ.)
9:15 a.m.- 9:30 a.m.	J4	"Observation of Space-Resolved Non-Uniformities and Energy Smoothing Effects on Plane Targets at 0.35 μm Laser Irradiation", G. Thiell, B. Meyer (Limeil)
9:30 a.m.- 9:45 a.m.	J5	"2-D Lasnex Ray Trace Studies of Thermal Self Focusing in Cylindrical Geometry", K. Estabrook, and W.L. Kruer (LLNL)
9:45 a.m.- 10:00 a.m.	J6	"Hydrodynamic Calculations of Thermal Self-Focusing in Laser Plasmas", R.S. Craxton and R.L. McCrory (LLE)
10:00 a.m.- 10:15 a.m.	J7	"Interactions of a Laser-Produced Plasma with a Magnetized Background Plasma", B.H. Ripin, J. Grun , M.J. Herbst, S.J. Kacenjar, K.J. Kearney, E.A. McLean, S.P. Obenschain, J.A. Stamper, F.C. Young, J.D. Huba and R.A. Smith (NRL)
10:15 a.m.- 10:30 a.m.	J8	"Experiments on the Rayleigh Taylor Instability of Ablatively Accelerated Targets Using Face-on X-ray Backlighting", J. Grun, M. Emery, M.J. Herbst, S. Kacenjar, E.A. McLean, S.P. Obenschain , B.H. Ripin, and M. Fink (NRL)
10:30 a.m.- 11:00 a.m.		COFFEE BREAK
11:00 a.m.- 11:15 a.m.	J9	"Analytic Models for Rayleigh Taylor Stabilization by Smoothe Density Profile, Vortex Shedding, Slab Compressibility, Thermal Conduction and Ablation", M. Manheimer and G. Colombant (NRL)
11:15 a.m.- 11:30 a.m.	J10	"Hydrodynamic Efficiency Measurements in Planar Geometry", L.M. Goldman, T. Boehly, W. Seka, R.S. Craxton (LLE)
11:30 a.m.- 11:45 a.m.	J11	"Theoretical Aspects of the Plasma Evolution from Gold Disks", R.R. Johnson, C.L. Shepard, G.E. Busch (KMSF)
11:45 a.m.- 12:00 p.m.	J12	"Vortex Shedding, Magnetic Fields and Flux Inhibition", H. Emery J.H. Gardner and J.P. Boris (NRL).
12:00 p.m.- 12:15 p.m.	J13	"A New Shock Wave and Its Application to Inertial Confinement Fusion", R.D. Jones, B. Bezzerides, J. Saltzman, and C.H. Aldrich (LANL)
4:30 p.m.- 6:30 p.m.		BARBECUE PARTY

Session K

6:30 p.m.- 7:30 p.m.	INVITED REVIEW ON RADIATIVE TRANSPORT , K. Whitney,(NRL)

7:30 p.m.- 8:00 p.m. Discussion,
Discussion Leader: D. Attwood, LLNL

Session L

8:00 p.m.- 11:00 p.m. HYDRODYNAMICS (poster)

L1 "0.53 μm Interaction Experiments With Long Scalelength Plasmas", R.E. Turner, R.P. Drake, D.W. Phillion, F. Ze, E.M. Campbell, K. Estabrook, B.L. Lasinski, W.C. Mead (LLNL)

L2 "Short-Pulse Experiments at Novette Laser Facility", D.L. Matthews, R.L. Kauffman, C. Wang, P.H. Lee, R.P. Drake, E.M. Campbell, P. Hagelstein, and K. Estabrook (LLNL)

L3 "Magnetic Bubble Formation Produced by an Expanding Laser Plasma", S.T. Kacenjar, J.A. Stamper, B.H. Ripin, J. Grun, and E.A. McLean (NRL)

L4 "Plasma Density Distributions from Laser-Irradiated Au Disk Targets", C.L. Shepard, R.R. Johnson and E. Busch (KMSF)

L5 "Mass Ablation Rates and Ablation Pressures in Planar Targets", A. Ng, D. Pasini, J. Kwan and P. Celliers (University of British Columbia)

L6 "Nonlinear Development of the Rayleigh-Taylor Instability of a Thin Sheet in Three Dimensions", D.G. Colombant, W.M. Manheimer and E. Ott (NRL)

L7 "A Comparison of Short and Long Pulse 1 μm Laser Produced Plasma Behaviour", M.D.J. Burgess, R. Dragila, B. Luther-Davies, K.A. Nugent, A. Perry, G.J. Tallents (Australian National Univ.)

FRIDAY, June 10

Session M SHORT WAVELENGTH, LONG SCALELENGTH, TARGETS (oral),
Chairman: R.R. Johnson, KMS Fusion

8:30 a.m.- 8:45 a.m. M1 "Improvement of Implosion in New Type Targets", C. Yamanaka (Osaka Univ.)

8:45 a.m.- 9:00 a.m. M2 "Update on the First Novette Experiments", R.P. Drake, R.E. Turner, D.W. Phillion, E.M. Campbell, F. Ze, W.C. Mead, B.L. Lasinski, K. Estabrook (LLNL)

9:00 a.m.- 9:15 a.m. M3 "First Analysis of Early Novette Experiments", W.C. Mead, R.P. Drake, E.M. Campbell, R.E. Turner, D.W. Phillion, W.L. Kruer, B.F. Lasinski, K.G. Tirsell, and C. Wang (LLNL)

9:15 a.m.- 9:45 a.m.	M4	"Comparison of Laser-Plasma Interaction at λ = 1.3 μm and 0.44 μm", A.G.M. Maaswinkel, G.P. Banfi, K. Eidmann, E. Fill, R. Sigel, G.D. Tsakiris, S. Witkowski (Garching)
9:45 a.m.- 10:00 a.m.	M5	"Hydrodynamic Modeling of Longer-Scalelength Interaction Experiments", J.H. Gardner, M.H. Emery, J. Grun, M.J. Herbst, R.L. Lehmberg, E.A. McLean, J.A. Stamper, F.C. Young (NRL)
10:00 a.m.- 10:15 a.m.	M6	"Longer-Scalelength Plasma Perturbations by an Intense Laser Beam", J.A. Stamper, F.C. Young, M.J. Herbst, S.P. Obenschain, J.H. Gardner, R.H. Lehmberg, E.A. McLean, (NRL) J. Grun, K.J. Kearney, (MRC), B.H. Pipin (NRL)
10:15 a.m.- 10:30 a.m.	M7	"X-Ray Production in Long Scalelength Interaction Experiments", F.C. Young, M.J. Herbst, J.H. Gardner (NRL), K.J. Kearney (MRC),J.A. Stamper, S.P. Obenschain, J. Grun (MRC) R.H. Lehmberg, E.A. McLean, B.H. Ripin (NRL)
10:30 a.m.- 10:45 a.m.	M8	"Longer-Scalelength Interaction Experiments: Observations of Scattered Light", M.J. Herbst (NRL), J. Grun (MRC), J.H. Gardner (NRL), K.J. Kearney (MRC), R.H. Lehmberg, E.A. McLean, S.P. Obenschain, J.A. Stamper, F.C. Young, B.H. Ripin (NRL)
10:45 a.m.- 11:00 a.m.		COFFEE BREAK
11:00 a.m.- 12:30 p.m.		FINAL DISCUSSION and NEXT YEAR'S MEETING, A.A. Offenberger, University of Alberta

SESSION A

Parametric Interactions (oral)

Monday, June 6
8:30 a.m.—12:15 p.m.

N.C. Luhmann, Jr., Chairman
University of California
Los Angeles

SATURATION AND HARMONICS OF THE ION WAVE IN SBS

C~~.~~hris E. Clayton, C. Joshi, F. F. Chen
University of California, Los Angeles

Collective Thomson scattering is used to study the growth and saturation of the ion acoustic wave excited in a 0.02 n_c gas-target plasma by stimulated Brillouin scattering (SBS). Detailed spatial measurements reveal that the ion wave varies exponentially in space in accord with the convective SBS theory at low pump intensities. However, at higher intensities, the peak of the ion wave broadens out indicating that the ion wave becomes saturated at an amplitude of about 10%.

The ion wave spectrum is measured from $\lesssim 2k_o$ to $\gtrsim 6k_o$ (k_o is the CO_2 pump wavevector). Discrete second and third harmonics are observed indicating that the ion wave is distorted from a pure sinusoid as might be expected from harmonic generation due to wave steepening. However, the dependence of the amplitude of the harmonics on pump intensity as well as their spatial variation do not suggest that harmonic generation is causing, or caused by, the observed ion wave saturation.

Temporally and Spectrally Resolved Backscatter Measurements at 10.6 μm

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K1A 0R6

Abstract:

We have employed a novel diagnostic[1] based on the Kerr effect to temporally and spectrally analyse the radiation near 10.6 μm which is backscattered during CO_2 laser plasma interaction. Simultaneous resolutions $\Delta\lambda \sim 30A$, $\Delta\tau \sim 80$ psec were achieved. Several features of the results are noteworthy:

1) the backscatter lasts for a shorter period of time than the ion waves at $2\ K_o$ as seen previously;[2]
2) at high CO_2 energies (> 5J), a strong red shifted component is observed. This shift increases with time over a ∼ 300 psec period, and reaches magnitudes ∼ 4 times larger than the expected shift, $\Delta\lambda \sim 2C_s\lambda o/C$; and
3) there is a near periodic modulation in the spectrum.

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[1] H.A. Baldis, C.J. Walsh and R. Benesch, Applied Optics (in press).

[2] C.J. Walsh and H.A. Baldis, Phy. Rev. Lett. 48 1483 (1982).

Ion Trapping and Heating
in Stimulated Brillouin Scattering

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Canada

Experimental observations of convective growth of stimulated Brillouin backscattering in CO_2 laser-plasma interaction can be explained by a refined model of ion trapping and heating. Backscatter reflectivity and spectral measurements indicate that ion temperatures $O(ZT_e)$ are obtained. Also, the long instability risetime ($\gtrsim$ 400 ps) measured in backscattered light and ruby laser Thomson scattering from the SBS associated ion fluctuations give further evidence for strong ion heating. The absorption of ion acoustic wave energy due to ion heating can account for these risetimes. A simple model of ion trapping and heating is used to interpret the results.

ABSOLUTELY UNSTABLE STIMULATED BRILLOUIN SCATTERING IN INHOMOGENEOUS PLASMA

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ABSTRACT

It is well known that, in an inhomogeneous plasma, stimulated Brillouin backscattering is convectively but not absolutely unstable. This conclusion remains valid for obliquely scattered light waves except for two angles where the derivative of the wavenumber mismatch at the phase matching point is zero. For these angles, stimulated Brillouin scattering is absolutely unstable above a threshold value. For obliquely incident lasers, there is one angle of scatter for which the phase is independent of space provided the temperature gradient is zero. For this case, the threshold is determined by damping or the finite plasma size.

EFFICIENT WAY TO PREVENT REFLECTION FROM STIMULATED BRILLOUIN BACKSCATTERING

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The same physical mechanism which causes stimulated Brillouin backscattering of a laser pulse when interacting with the underdense plasma (in laser fusion systems) can be used to reverse the scattering direction in order to drastically reduce the reflection loss. Forced stimulated rescattering may be obtained by additional radiation pulses or by a multihumped spectrum, each peak (or satellite) downshifted by twice the acoustic frequency. Analytical four mode and numerical six mode models, in the heavy sound wave damping limit, show strong reduction of the reflectivity. E.g. 20% additional intensity for one downshifted satellite reduces the reflectivity by a half, before strong pump depletion, and the reflection coefficient is reduced to one third of the single scattering value when the input spectrum has two downshifted satellite lines. Finite spectral interaction of the narrow ingoing lines with the broad backscattered spectra are tested by the nonlinear integrodifferential ion-Compton equations. A small quantitative modification does not significantly change these qualitatve results.

A6

13th ANNUAL ANOMALOUS ABSORPTION CONFERENCE
Banff, Alberta, June 5-10, 1983

Absolute instability criterion for parametric decay wave processes with nonuniform coupling

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ABSTRACT

For one-dimensional three-wave parametric instabilities with oppositely directed group velocites for the decay waves in unbounded plasmas, it is known that for uniform coupling amplitude and constant wavevector mismatch ($d\Sigma k_i/dx$ = constant) there cannot be an absolute instability. We show that this is an exceptional case, and that in general an absolute instability can always be obtained in an inhomogeneous plasma with a sufficiently strong pump. A simple criterion is given for the threshold of the absolute instability.

D2

Abstract Submitted for the Thirteenth Annual Anomalous

Absorption Conference

Banff, Alberta

June 5-10, 1983

THE CONVECTIVE RAMAN INSTABILITY*

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University of Rochester
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We present improved calculations of the convective gain coefficient of stimulated Raman Scattering (SRS) in an inhomogeneous low density plasma using a Vlasov description for the electron plasma waves. This allows a more precise determination of the relation between the observed cutoff of the SRS spectra at short wavelengths and the electron temperature on the corona.

*This work was partially supported by the U.S. Department of Energy Inertial Fusion Project under contract number DEAC0880DP40124 and by the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics.

LANGMUIR WAVES IN A PERIODIC STRUCTURE

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ABSTRACT

The propagation of electron plasma waves in a periodic medium is examined using a Vlasov description. A dispersion relation is derived and analyzed. Estimates are obtained for the modification of the Landau damping rate due to the periodic modulation of the medium. The results are discussed in the context of concurrent Rama and Brillouin scattering which has been studied by Rozmus, e al.[1]

Rozmus, et al. - to be published (Phys. Fluids).

Kinetic model for plasmas
in the underdense region

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Canada

A kinetic model is presented for stable plasma in the presence of a strong electromagnetic pump wave. Ion dynamics are properly treated to account for enhancement in electrostatic fluctuations. The latter, induced by particle discretness, are especially important in the subthreshold regime for oscillating two-stream and parametric decay instabilities in the underdense region. The thresholds of these instabilities are numerically found for $0.5<n_e/n_{cr}<0.8$. The results of the calculations for a static form factor $S(\underline{k})$, electron collision terms and absorption coefficient are presented. For the pump values $0.05<V_{osc}/V_{the}<2$ enhanced fluctuations levels and increased absorption are found.

Anomalous Absorption, Banff, June 1983.

~~A10~~ A8

Half Integer Harmonic Radiation from Laser Plasmas.*

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Laboratory for Laser Energetics, University of Rochester, Rochester, N.Y.

We have investigated $\omega/2$, $3\omega/2$, and $5\omega/2$ radiation from plasmas produced by 1.05 and 0.35μm lasers with pulse widths ranging from 0.5 to 1 ns and intensities between 10^{13} and 10^{15} W/cm^2. Both planar and spherical geometry were used in these experiments. Our data suggest the same thresholds for all half integer harmonics (HIH) indicating a common constituent, namely, the plasma waves of the $2\omega_p$ decay instability at $n_c/4$. All HIH spectra consist of two broad lines whose relative intensities and splittings depend to varying degrees on the intensity and target Z.

While the $\omega/2$ radiation is essentially unpolarized the $3\omega/2$ radiation is strongly polarized parallel to the laser radiation. Both types of spectra are essentially independent of angle of observation between 0 and 45°. Most models used to explain any of the half-harmonic spectra require convection and/or scattering of the plasma wave vectors prior to the generation of the HIH radiation. A discussion of various possible generation mechanisms will be given. From our $3\omega/2$ data it would appear that these spectra may be effectively used for coronal temperature diagnosis through the $3\omega/2$ line splitting $\Delta\lambda/\lambda_c \simeq T_{keV}/511$. (Note: For 10 μm irradiation this relationship requires correction terms.)

The $\omega/2$ radiation may be thought as generated by an inverse resonance absorption process. The splitting of this double line structure appears to scale faster than the expected $\Delta\lambda \propto T$ scaling. The origin of this dependence is not yet clear.

The $5\omega/2$ spectra from 1.05 μm laser plasmas may be generated by scattering of 2ω photons off plasmons at $n_c/4$. The 2ω photons could be those generated near n_c by scattering of laser photons on plasma waves generated by resonance absorption and/or the parametric decay instability. Since the $5\omega/2$ intensity is rather low no systematic study has yet been conducted but the splitting of these spectra is consistent with that observed for $3\omega/2$.

In summary, HIH spectra are a clear manifestation of laser driven instabilities in the plasma near $n_c/4$, viz. the $2\omega_p$ instability. The spectra can be used to diagnose the plasma conditions near $n_c/4$. Unfortunately, the k-matching conditions for the generation of these spectra are such that none of the scattering processes are likely to occur exactly at the point where the instability occurs. This significantly complicates the theoretical interpretation and reduces the reliability of simple application of these spectra to coronal plasma diagnosis.

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*This work was partially supported by the U.S. Department of Energy Inertial Fusion Project under contract No. DE-AC08-80DP40124 and by the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics.

3/2 ω_0 EMISSION FROM UNDERDENSE PLASMAS

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K1A 0R6

Emission of the 3/2 harmonic of the incident laser light is generally thought to be due to either the scattering of a photon off a plasmon, or the coalescence of three plasmons. The plasmons are produced at the quarter-critical surface primarily by the two-plasmon decay instability. Such emission provides a diagnostic for the presence of this instability.

We report here on measurements of the emission of 3/2 ω_0 light from preformed underdense plasmas of variable peak density and scale length, heated by a 1 ns 5 x 10^{13} W/cm^2 CO_2 laser beam. The 3/2 ω_0 emission shows a rapid nonlinear growth with intensity, and is greatest at 0^o and 90^o to the CO_2 beam. Backreflection into the lens is polarized parallel to the incident beam, whereas the sidescatter is less strongly polarized, and is independent of the polarization of the incident beam. The emission disappears when the peak plasma density is less than quarter-critical.

Anomalous Absorption, Banff, June 1983.

Spectroscopic Study of Second Harmonic Emission from Spherically Irradiated Plasmas with $\lambda_L = 1.054$ µm.*

K.Tanaka, L.M.Goldman, M.C.Richardson, W.Seka, J.Soures, R.Short, E.A.Williams.

Laboratory for Laser Energetics, Univ. of Rochester, Rochester, N.Y.

Spectroscopic measurements have been made of the fundamental and the second harmonic ($2\omega_L$) light emitted by spherically irradiated plasmas. Stokes and anti-Stokes components were found on the $2\omega_L$ spectra separated typically by $\Delta\lambda = 18$ Å independent of target material. However, the intensities and spectral widths of these peaks are very sensitive to the irradiation intensity. No corresponding structure was found in the scattered light spectrum around the fundamental wavelength.

The experiment was conducted on the 24-beam OMEGA laser system ($\lambda_L = 1.054$ µm, $t_L = 1$ nsec, $E_L \leqq 2$ kJ, $I_L \leqq 5\mathrm{x}10^{14}$). Targets were CH, Cu coated, and Ta coated spheres as well as glass microballoons (GMB).

Spatially resolved images of $2\ \omega_L$ light can be characterized by a strong central lobe in addition to limb brightening. This cental lobe is consistent with $2\ \omega_L$ radiation due to scattering of incident photons from plasmons excited by resonance absorption. From the k-matching conditions for this process, we expect this radiation to be emitted preferentially along the density gradient. Possible interpretations of the observed limb brightening rely on the different competing mechanisms around the critical density which could generate plasmons perpendicular to the density gradient.

Resonance absorption also explains the observed intensity dependence of the $2\ \omega_L$ light, which is

$$E_{2\omega}/E_{inc} \propto I_{inc}^{1.6},$$

where $E_{2\omega}$, E_{inc}, and I_{inc} are the $2\omega_L$ energy, the incident energy, and the incident laser intensity, respectively. The scaling reflects the decrease in inverse bremsstrahlung absorption and the concomitant increase in resonance absorption.

Details of $2\omega_L$ spectra were measured over three orders of the signal intensity with a spectral resolution of $\Delta\lambda = 2$ Å. The $2\ \omega_L$ spectra had as many as six down-shifted peaks periodically spaced on the red side with succesively decreasing intensity. This structure is very clear at $I_L \simeq 7.0\mathrm{x}10^{13}$ W/cm^2 while, at higher intensities, it merges into a continuum of the red side of the main peak. Up-shifted peaks were also observed for GMB's and Ta targets for $I_L \gtrsim 2\mathrm{x}10^{14}$ W/cm^2. At the same time, the spectra of both specularly and back-reflected fundamental light (ω_L) showed no such structures. The generation mechanisms of these features in the $2\omega_L$ spectra will be discussed in terms of parametric processes occuring near the critical density, including the decay instability[1, 2] and stimulated scattering of the electron plasma waves excited by resonance absorption.

1. N.G. Basov, et al, Sov. Phys. JETP, 49(6), 1059, (1979).
2. C. Yamanaka, et al, Phys. Rev. Lett., 32, 1038, (1973).

*This work was partially supported by the U.S. Department of Energy Inertial Fusion Project under contract number DE-AC08-80DP40124 and by the Laser Fusion Feasibility at the Laboratory for Laser Energetics.

SESSION B

Invited Review on Strong Turbulence

R. PELLAT
Ecole Polytechnique

Monday, June 8
6:30 p.m.—7:30 p.m.

Discussion
7:30 p.m.—8:00 p.m.

W. M. Manheimer, Discussion Leader
Naval Research Laboratory

SESSION C

Parametric Interactions (poster)

Monday, June 6
8:00 p.m.—11:00 p.m.

26

Abstract Submitted
for the

13th Annual Anomalous Absorption Conference

June 5-10, 1983
The Banff Centre, Banff, Alberta

MILLIMETER WAVE SCATTERING MEASUREMENT OF THE GROWTH AND SATURATION OF ION WAVES IN A MICROWAVE-PLASMA INTERACTION EXPERIMENT*

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University of California
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ABSTRACT

We have previously reported on the growth and saturation of ion waves produced both by optical mixing(1) and SBS (2,3,4) in a microwave plasma interaction experiment. In both cases the ion waves were measured with probes after turn-off of the rf pump in order to avoid the well known problems associated with sheath nonlinearities in the presence of intense rf fields. More recently, however, we have made nonperturbing measurements of the ion waves during the pump probe via collective far-infrared (FIR) collective Thomson Scattering (5,6).

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

References

(1) Pawley, C.J., Huey, H.E., and Luhmann, N.C., Jr., Phys. Rev. Lett. 49, 877 (1982).

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(5) Peebles, W.A., Luhmann, N.C., Jr., Mase, A., Park, H., and Semet, A., Rev. Sci. Instrum. 52, 360 (1981).

(6) Park, H., Yu, C.X., Peebles, W.A., Luhmann, N.C., Jr., and Savage, R., Rev. Sci. Inst. 53, 1535 (1982).

Stimulated Scattering of a Strong KrF Pump in a Plasma Waveguide

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Canada T6G 2E1

One way of temporally compressing a KrF laser beam to parameters of relevance to fusion would consist of parametrically coupling a long energetic pump to a short Stokes pulse as the two counter-propagate in a plasma waveguide. The success of this scheme relies on the possibility of propagating an energetic laser beam in a long plasma cylinder without suffering significant depletion losses by stimulated scattering or other non-linear processes. In this paper we examine the possibility of depleting a strong KrF laser beam by stimulated back or forward scattering as it propagates in a plasma waveguide.

C3

Ion Turbulence in Laser Plasma Interactions

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Department of Electrical Engineering
University of Alberta

and

A. Ng
Physics Department
University of British Columbia

Ion turbulence generated in a CO_2 laser heated plasma has been studied using ruby laser Thomson scattering. The first detailed measurement of the ion fluctuation spectrum, S(k), induced in the plane of the laser electric field by a high intensity focused CO_2 laser beam has been made and is reported here. The fluctuation levels, measured in this plane, could be as high as that induced by strong parametric interaction such as SBS. High speed streak measurements of the Thomson scattered light indicate very short duration (~1 ns) and fast rise-time (~50 ps) features in the enhanced ion fluctuations.
These results are discussed in the light of analytical theory and computer simulations of Estabrook and Kruer.

C4

OPTICAL MIXING AND SRS IN A θ-PINCH PLASMA

Behrouz Amini and Francis F. Chen
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Stimulated Raman backscatter has been observed at the expected time in a reproducible theta-pinch plasma under well diagnosed conditions. The Raman spikes occur at the peak of the laser input when it is fired at the time of maximum compression. The growth and saturation of the backscattered light have been measured. To compare with theory, the plasma conditions are carefully diagnosed. The density and its uniformity are measured by axial and radial ruby-laser interferometry. The axial views give the radial density profile without Abel inversion, and the radial views give the scalelength and the absolute density after Abel inversion with a known profile. The ion temperature is measured by pressure balance and by Doppler broadening of He II 4686 A. The electron temperature is measured by the line-to-continuum ratio of 4686 A and, hopefully, by measuring the Bohm-Gross frequency by Thomson scattering and by the appearance of Stark satellites.

The initiation of SRS by optical mixing can be studied by injecting a weak beam at 10.26 μm in the direction opposite to the main beam at 9.6 μm. A tricky optical arrangement suppresses the effects of non-resonant SRS and of light from the regions where the beams do not overlap. An enhancement of the lower frequency beam is observed whenever the plasma density satisfies the condition $\omega_p = \Delta\omega$.

C5

1 1/2 D SIMULATION OF RAMAN SCATTERING

A. Alfheim, A.J.Barnard and E. Hiob
University of British Columbia, Vancouver, BC, Canada

Forward and backward stimulated Raman scattering of laser light by plasmas has been simulated in 1 1/2 D by both a particle and a Vlasov code. The scattering has been studied for a uniform plasma and periodic boundary conditions over a range of laser intensities. At higher irradiances the effective damping of the plasma wave is greatly increased as electrons are trapped in the wave. Since the trapped electrons can attain high velocities, they must be treated relativistically. A relativistic model, which yields expressions for the trapping threshold and for the number of trapped electrons, has been developed. Forward scattering dominates at high temperatures and produces faster trapped electrons.

The simulation is presently being extended to the case of a laser beam propagating into a plasma with linearly increasing density.

FILAMENTATION OF LIGHT WITH A DIFFUSE ANGULAR SPREAD

A. Bruce Langdon

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University of California, Livermore, CA, 94550

I consider filamentation by the ponderomotive force mechanism for the situation in which the light consists not of a single plane wave but of many, non-parallel beamlets. With a diffuse spread of angles, the analysis to be presented shows that filamentation is ***stabilized*** if the angular spread $\bar{\theta}^2$ is large enough:

$$\bar{\theta}^2 \gtrsim \frac{1}{4}\,\frac{n}{n_c}\,\frac{\bar{v}_0^2}{v_e^2}$$

where $v_e^2 \equiv T_e/m_e$ and $\bar{v}_0^2$ represents the electron's oscillatory velocity corresponding to the *sum* of intensities, i.e. $\bar{v}_0^2/v_e^2 = 4\times10^{-16}\sum I\lambda^2/T_e$ (W/cm^2, μm, keV). My analysis begins by extending the dispersion relation[1] which describes filamentation (and Brillouin scatter). The components of the beam are assumed to be "sufficiently" mutually incoherent.

The reason for this stabilization is as follows: Consider a component of the light whose $\mathbf{k}_0$ makes a sufficient angle to the filament. The magnitude of the electric field in the low density plasma inside the filament is smaller than outside (just as the electric field increases as a wave approaches critical density). This is the opposite of the situation for a component of light with $\mathbf{k}_0$ almost parallel to the filament which is intensified by focusing. It is clear that the oblique components of the diffuse light not only do not contribute to the self focusing mechanism, they *oppose* it. Hence they can provide stabilization, not just a lowered growth rate. The same argument holds for filamentation by the thermal mechanism.

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

[1] L. M. Gorbunov, *Zh. Eskp. Teor. Fiz.* 55, 2298 (1968) [*Sov. Phys.-JETP* 28, 1220 (1969)]; J. Drake, P. K. Kaw, Y. C. Lee, G. Schmidt, C. S. Liu and M. N. Rosenbluth, *Phys. Fluids* 17, 778 (1974); W. M. Manheimer and E. Ott, *Phys. Fluids* 17, 1413 (1974).

Temporal and Spectral Behavior of Stimulated Backscatter in a CO_2 Laser-Gas Jet Experiment*

J.E. Bernard, J. Meyer, H. Houtman, B. Hilko, G. McIntosh, and R. Popil,

University of British Columbia

A short pulse (~2ns) CO_2 laser beam with a peak intensity of ~$5x10^{13}$ W/cm^2 has been focussed onto a laminar nitrogen gas jet target to produce a subcritical plasma with N_e~$5x10^{18}cm^3$ and T_e~1-2 KeV. The backscatter attributed to stimulated Brillouin scattering has been temporally resolved on a subnanosecond time scale and spectrally resolved using a spectrometer and image dissector. Temporally, the backscatter first appeared after the peak of the incident pulse and was observed to be double peaked at the highest laser intensities. The maximum reflectivity was of the order of 10%. Spectra were obtained for a range of incident laser intensities and indicate that the scattering originated from several regions of plasma. These results will be presented and discussed in terms of possible models.

* This work supported by a grant from NSERC.

C9

OBSERVATIONS OF HOT ELECTRON SPECTRA PRODUCTED BY STIMULATED RAMAN SCATTERING*

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Seattle, Washington 98195

ABSTRACT

Fast electrons have been observed to emanate from an underdense plasma simultaneously with stimulated Raman scattering. These electrons have an apparent Maxwellian energy distribution when integrated over time with temperatures from 29 to 105 keV. The hot electrons have been detected as bursts correlated with SRS backscatter pulses, and are directed primarily into the forward direction.

The target plasma was preformed by the collision of two shock waves produced by coaxial discharge guns similar to Marshall guns. This resulted in an unmagnetized Argon plasma with density $\sim 5\times10^{17}$ cm^{-3} (but everywhere $<1/4\ n_{cr}$), scale length of ~1 cm, and a diameter of ~3 cm, that persisted for several microseconds. The temperature was estimated to be 2-5 eV, but rose to ~100 eV in the region of laser interaction.

A gain switched, electron beam stabilized CO_2 laser was used to drive the SRS. Stimulated Brillouin backscattering was also produced, which provided feedback to the laser and modified the normal output so that a large spike followed by a series of smaller pulses separated by the transit time through the optics were produced. The maximim intensity on target was $\sim 10^{11}$ W-cm^{-2} with f/7 optics, giving quiver velocity ratio V_o/c of $\sim 3\times10^{-3}$.

Computer simulations[1] have indicated that $T_{hot} \simeq 1/2\ mv_{\phi}^2$, where v_{ϕ} is the phase velocity of the Langmuir wave. Our experimental conditions would give $T_{hot} \simeq 4$ keV using the phase velocity $\omega_{pe}/2k_o$ for backscattering in the interaction region, which is inconsistent with the measured T_{hot}, indicating sidescattering, $v_{\phi} > \omega_{pe}/2k_o$, or other possibilities.

References

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

HOT ELECTRON GENERATION FROM PLASMA WAVE DAMPING IN THE PRESENCE OF A MAGNETIC FIELD

W. Mori, C. Joshi, F. F. Chen[1], J. M. Dawson, and R. Huff[2]

1-Department of Electrical Engineering and
2-Department of Physics-UCLA.

Experiments and computer simulations show that large self-generated magnetic fields exist in laser fusion plasmas. Motivated by this fact we have conducted computer simulations employing a 1-2/2-D relativistic electromagnetic particle code in order to study hot electron generation due to the damping of electron plasma waves in the presence of an imposed d.c. magnetic field. The plasma wave was excited by beating two lights waves, propagating either parallel or counter-parallel to each other, such that their frequency difference equals the plasma frequency to simulate excitation from the stimulated Raman forward or backscattering instability. The electric field of the laser was polarized along the d.c. magnetic field. Runs were carried out for various magnetic field strengths.

We will show that in certain regimes, relevant to laser fusion, the magnetic field can have profound effects on the generation of hot electrons. In particular, when the plasma waves' electric field, E, is larger than $\gamma_\phi B$ electrons remain trapped at a fixed point in the potential trough and move across the wave fronts. Here $\gamma_\phi = (1 - v_p^2/c^2)^{-\frac{1}{2}}$ where v_ϕ is the phase velocity of the plasma wave. Whereas when E is smaller than $\gamma_\phi B$ electrons become detrapped and do not gain as much energy.

Work supported by Lawrence Livermore Laboratory under the University Research Program grant number, DE-AS08-81DP-40163 and 40136.

C12

Trapping of Plasma Waves in Cavitons

by

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Los Angeles, California 90024

The observed characteristics of electron plasma waves trapped inside a density cavity, a caviton, verify quantitatively the predictions of the nonlinear Schorödinger equation including the ion dynamics. A two-frequency excitation technique was used to demonstrate the existence of eigen-modes for the trapped electron plasma waves in a caviton.

Supported by U.S. Dept. of Energy

SESSION D

Parametric Interactions, Hot Electrons, Fast Ions (oral)

Tuesday, June 7
8:30 a.m.—11:45 a.m.

R. Fedosejevs, Chairman
University of Alberta

Abstract Submitted for the Thirteenth Annual Anomalous
Absorption Conference
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June 5-10, 1983

ON THE INHOMOGENEOUS TWO PLASMON INSTABILITY*

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The two plasmon instability in warm inhomogeneous plasma for a normally incident pump is considered. The complex eigenfrequencies of the absolute instability are obtained by reducing the linearized fluid equations to a Schroedinger equation in wave-number space. These eigenvalues are obtained in several ways. One is by combining a perturbation expansion in powers of the reciprocal scale length with WKB theory. The resulting algebraic equations are solved by three analytic approximations or by direct numerical solution. A second way is by analysis of the Schroedinger equation using an interactive WKB computer code. A third way is by use of a shooting code. These methods are all used and compared for threshold curves and growth rates above threshold. Some eigenfunction forms are also obtained.

The threshold is near $(v_o/v_e)^2 k_o L = 3$, and varies weakly with $\beta \simeq v_e^4/v_o^2 c^2$, rising from near 2 to about 4 over six decades of variation of β. The corresponding critical value of $(k_y/k_o)^2$ is near $2/_3$ over this range. Above threshold, there is a smooth variation of growth rate with $(k_y/k_o)^2$, peaking at some intermediate value. The perturbation method is in good agreement there with more exact calculations. Experimental implications of these results are discussed.

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* This work is supported by the sponsors and participants of the laser Fusion Feasibility Project of the Laboratory for Laser Energetics.

~~D2~~
A10

Abstract Submitted for the Thirteenth Annual Anomalous
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June 5-10, 1983

THE TWO-PLASMON INSTABILITY IN A FILAMENT*

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Rochester, New York 14623

A simple model has been used to investigate the two-plasmon decay of laser light trapped in a filament. This process will occur in the vicinity of quarter-critical density in the wall of the filament. We represent this region as a linear density profile with the pump light propagating perpendicular to the density gradient. Requiring that the instability be absolute along the density gradient, we obtain expressions for the threshold and growth rate in terms of the pump intensity, density scale length and electron temperature.

The generation of half-integer harmonic light by the interaction of the decay plasmons with the pump provides one of the most important diagnostics for the two-plasmon decay process. By requiring plasmon and photon wave-vector matching in the generation process and using our expressions for threshold and growth rate as a function of plasmon wave-vector, we calculate the spectral characteristics of the emitted $\frac{3}{2}\omega_o$ light as a function of observation angle. These results will be compared with experimental observations.

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*This work is supported by the U.S. Department of Energy inertial fusion project under contract No. DE-AC08-80DP40124.

EXPERIMENTAL INVESTIGATION OF ENERGETIC ELECTRONS PRODUCED AT THE QUARTER CRITICAL DENSITY IN CO_2-PLASMA INTERACTION.

J. Meyer, J.E. Bernard, B. Hilko, H. Houtman,
G. McIntosh and R. Popil

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The production of fast electrons by both the two plasmon decay (TPD) and the stimulated Raman scattering (SRS) instabilities in a CO_2 laser irradiated laminar N_2 gas jet is investigated. Analysis of TPD electrons and backscattered $\frac{3}{2}\,\omega$ radiation indicate that electrostatic waves of initially 1.8 laser wavenumbers trap electrons and subsequently heat them to energies exceeding the phase energy by a factor of five whilst SRS electrons are observed at the phase energy of the absolute instability. More than 1% of all electrons in the focal volume are ejected at KT > 50 KeV. Interferometric studies of the quarter critical density scale length indicate that the time and intensity dependence of both instabilities is dominated by density profile modification.

D4

13th ANNUAL ANOMALOUS ABSORPTION CONFERENCE
Banff, Alberta, June 5-10, 1983

Fast electrons from localized strong travelling waves

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and
V. Fuchs
Institut de recherche d'Hydro-Québec (IREQ)
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ABSTRACT

The single pass version of simple model of Fuchs et al[1] sheds light on the production of fast electrons, the relation with quasilinear diffusion and strong field effects. Input/output data and the related "scattering" matrices (e.g.. $P(V_{out}/V_{in})$) are presented as convenient aids to understanding effects such as the lower velocity limit for onset of non adiabatic acceleration and the upper velocity range for effective acceleration. The application of these to parametric instability processes will be discussed.

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[1] V. Fuchs, V. Krapchev, A. Ram and A. Bers paper B-1.8 5th Topical Conference on RF Plasma Heating, University of Wisconsin, 21-23 Feb. (1983).

Instability Induced Hot Electrons in CO_2 Laser Plasmas

by

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Los Alamos, New Mexico 87545

We describe our most recent results on the heating of plasmas by CO_2 lasers. In partcular, we describe some very long scale length underdense plasma simulations under several input conditions: (1) multi-frequency input laser beams separated by plasma beat frequency, (2) variations in pulse length from a few psec to nearly a hundred psec, (3) variations in uniform plasma density from a few percent to near quarter critical, (4) variations in laser intensity from a few x 10^{14} W/cm^2 to a few x 10^{16} W/cm^2. As we previously reported, Raman is the dominant absorption mechanism in a highly underdense plasma producing a very hot electron tail consistent with the plasma energy density being comparable to the laser energy density. New results show that absorption per unit length decreases with increasing laser intensity for a fixed plasma density, yet absorption is large enough for example to generate a broad MeV electron spectrum for $I \sim 10^{16}$ W/cm^2. After some time, beat wave simulations produce a similar although higher broad electron spectrum as single frequency simulations. The most interesting result is that Raman can <u>absorb</u> most of the input laser energy yet produce less than a percent in scattered energy. We also observe in two dimensions the Weibel instability which isotropizes the lower energy electrons.

ABSTRACT 13th ANNUAL ANOMALOUS ABSORPTION CONFERENCE

Suprathermal electron transport in CO_2 laser plasma

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Ecole Polytechnique, Palaiseau, France

Axial and lateral hot electron energy profiles are inferred from continuum and characteristic X-ray emission for laser irradiances between $10^{\overset{12}{\cancel{13}}}$ and 10^{14} W/cm^2. Continuum X-ray emission is recorded with nine K edge filter detectors covering the 1-70 keV range. K_α emission is recorded with a multiple pinhole X-ray camera and PIN diodes filtered such that the difference between two images or signals gives the K_α emission of the target material. Spatial resolution of continuum and K_α emission is obtained directly from pinhole images and by using targets composed of an X-ray emitter disc of various diameter on an infinite substrate and covered by plastic layer of various thicknesses. Energy deposition profiles and the geometry of energy deposition are thus obtained at various depth inside the target with two different diagnostics.

Quantitative results obtained from continuum and K_α are compared and discussed. Results show that the electrons deposit most of their energy at oblique angles on the target surface. The axial energy deposition profile is in good agreement with a planar semi-isotropic source of incident hot electrons. Near the focal spot, in 2 mm diameter zone, the hot electrons penetrate the target at near normal incidence, are less energetic and transport less than 10% of the total deposited energy (9% of the laser energy). Away from the focal spot the hot electrons are increasingly energetic and incident at oblique angles. The energy deposition geometry given by pinhole pictures at various depth inside the target is also presented and analysed. The physics of hot electron transport is discussed.

D7

Implications of Fluorescent Yield Measurements for Hot Electron Target Coupling in Planar Geometry

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K1A 0R6

The study of K_α emission from planar CO_2 laser target irradiation has provided direct information on hot electron target coupling efficiency and hot electron transport. A series of experiments using Ni fluors in structured and layered planar targets has indicated that at intensities of $\sim 4 \times 10^{14}$ W/cm^2 an amount of energy corresponding to 5 to 10% of the incident laser energy is coupled into the target in the focal vicinity by hot electrons with a temperature of 15 to 20 Kev. A similar fraction of the incident energy is deposited in a remote deposition zone extending a mm or so from the focal spot. Recently a Von Hamos spectrograph has been employed to record the spectrum of K_α like emission lines from Al targets. The relative intensity of K_α like emission from the various ionization stages of Al is a sensitive measure of both the target coupling efficiency and the hot electron temperature. The observed time integrated spectra can be duplicated for the hot electron temperature and energy flux parameters mentioned above in calculations which assume classical electron transport and equilibrium ionization. Experiments currently in progress to time resolve these spectra with an x-ray streak camera should provide information on the temporal development of the hot electron temperature and target cooling efficiency.

D8

Experimental study on pellet implosion by high power CO_2 laser " LEKKO VIII "

[illegible] electron temp

H.Fujita, H.Daido, H.Nishimura, R.Tateyama, K.Ogura, M.Fujita
M.Inoue, K.Terai, K.Sawai, S.Nakai and C.Yamanaka

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2-6 Yamada-oka, Suita, Osaka 565, Japan

[illegible]

CO_2 laser is one of the most feasible laser as a energy driver for a future reactor because of its high efficiency and high repetitive operation. The most important key issue in the pellet implosion by CO_2 laser is the investigation of the behavior of the hot electrons produced by the anomalous absorption processes. The hot electrons can transport the absorbed energy in coronal region to the ablation front and hence can efficiently generate the driving pressure for the target acceleration. Good lateral transport by the hot electrons may smooth out the irregularity of irradiation to get uniform ablation pressure, which suppress the growth of fluid instability. On the other hand, the long range of energetic electron may result in core preheat and then inefficient implosion. The implosion dynamics and the overall efficiency depend strongly on the design of pellet. The basic physics relevant to the hot electron driven implosion$^{1)}$ has been extensively investigated by LEKKO II, two beam 1 kJ CO_2 laser.

Pellet implosion experiments by the eight beam 10 kJ CO_2 laser LEKKO VIII$^{2)}$, which has been completed with good focusability (100-200 um), high S/N ratio (10^7) and high power of 1.2 TW/beam (920 J, 0.8 ns) are scheduled. Preliminary experiments on exploding compression of GMBs filled with D_2 gas have been done by using two beams of the LEKKO VIII to investigate the lateral transport of the hot electrons, the symmetry of the compression and the core plasma parameters. The experimental results were coincident with the results of 1D simulation (HIMICO), which suggested the uniform compression even with the two beam irradiation.

The implosion experiments on cannon ball target have also been started. The results showed highly uniform compression and the existence of physical mechanism to suppress the hot electron preheat.

1) H.Nishimura et al, Phys. Rev. A <u>23</u>, 2011 (1981)
2) C.Yamanaka et al, IEEE J. Quantum Electron. <u>QE-17,</u> 1678 (1981)

Abstract for the 13th Annual Anomalous Absorption Conference, June, 1983

Fast Ion Spectra: Comparison of Model Predictions with Measurements, D. MITROVICH, Western Research Corporation — Superthermal electrons in laser plasmas are thought to produce the fast ion component observed in the ion blow off spectrum and to cause preheating of the target core. The two temperature model of plasma electrons is formulated in spherical geometry and generalized to include energy transfer to the thermal electrons. In the model, the hot electron component is dominant only in the low density corona where it does expansion work on the ions. Each of the energy groups into which the component is separated deposits its remaining energy into the thermal electrons at that location to which the group's motion transports it, first by collisionless, then by diffusive means. The model was incorporated into a spherically symmetric, one electron temperature, hydrodynamic code. The resulting calculated ion blow off spectra correspond well with the experimentally measured spectra. Both spectra display a fast ion "bump" whose shape and location depends on the irradiation parameters. The good agreement with experiment indicates that the physical mechanism described by the model is largely responsible for the observed fast ions.

D11

The Production of Collimated Fast Ions from CO_2 Driver Targets

by

C.W. Barnes, D.W. Forslund, and G. Kyrala

The magnetic electron transport model of Forslund and Brackbill(1) predicts the efficent conversion of CO_2 laser produced hot electron energy to fast on blowoff. This suggests the possibility of drawing ICF capsules directly with these fast ions if they could be adequately collimated and focused. We have performed experiments and numerical simulations designed to determine the fast ion angular spectrum from flat targets illuminated by tightly focused CO_2 laser beams. The fast ion blowoff consists of a normal, collimated (less than 10° half cone angle) component and a diffuse component which carries a significant fraction of the total ion energy. Of the collimated ion energy, most is seen to originate within 100 μm of the laser spot although a large surface area around the laser spot (tens of mm) is required for best energy collimation. Simulation results give angular distributions in good agreement with the experiments and confirm that most collimated fast ions originate near the last spot.

(1) D.W. Forslund and J.U. Brackbill, PRL 48, 1614 (1982).

SESSION E

Invited Review on Non-Maxwellian Distribution Functions

W. KRUER,
Lawrence Livermore National Laboratory

Tuesday, June 7
6:30 p.m.—7:30 p.m.

Discussion
7:30 p.m.—8:00 p.m.

A.B. Langdon, Discussion Leader
Lawrence Livermore National Laboratory

Nonthermal Velocity Distributions in Laser-irradiated Plasmas

W. L. Kruer

Lawrence Livermore National Laboratory
University of California, Livermore, CA 94550

Modelling wave-particle interactions in a strongly-driven plasma is a challenging problem of great interest to both basic plasma physics and practical applications. Non-Maxwellian heated velocity distributions can be an important feature of laser plasma coupling. Such distributions strongly impact ICF applications and are often an intrinsic feature of the nonlinear state of the plasma. We present a tutorial overview of the heated velocity distributions generated by a wide variety of coupling mechanisms, including collisional absorption, resonance absorption and heating by a number of different laser-driven instabilities. Various approaches to describing the wave-particle interaction are described, and the frequent need to self-consistently evolve the waves and the distribution function is emphasized.

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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 F

Parametric Interactions, Hot Electrons, Fast Ions (poster)

Tuesday, June 7
8:00 p.m.—11:00 p.m.

EVIDENCE FOR ANOMALOUS TRANSPORT OF FAST ELECTRONS IN SPHERICAL GEOMETRY

J. A. TARVIN

KMS Fusion, Inc., Ann Arbor, MI48106

F3

The $2\omega_{pe}$ Instability in Current Experiments*

B. F. Lasinski, A. B. Langdon, W. L. Kruer, W. C. Mead,
R. E. Turner, E. M. Campbell, D. W. Phillion, and R. P. Drake

Lawrence Livermore National Laboratory
University of California, Livermore, CA 94550

The $2\omega_{pe}$ instability, the decay of the incident electromagnetic wave into two electron plasma waves, is difficult to quantify experimentally. Often its presence is inferred from $3\omega_0/2$ or $\omega_0/2$ emission, both of which result from the subsequent interaction of the decay plasma waves. Experimental evidence on the $2\omega_{pe}$ instability is reviewed in terms of expectations based on simulations and linear theory. Threshold estimates for the $2\omega_{pe}$ instability are extremely sensitive to the local plasma conditions, with collisional damping becoming more important for shorter incident wavelengths.

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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.

F4

13th ANNUAL ANOMALOUS ABSORPTION CONFERENCE

Angular dependence of scattered ω_0 and $2\omega_0$ radiation for CO_2 laser produced plasmas.

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G.R. Mitchel
Institut de Recherche d'Hydro-Québec, Varennes, Québec

ABSTRACT

Angular resolved measurements of the scattered energy and spectral distribution in the specular plane for CO_2 (10.6 μm) laser produced plasma are interpreted in terms of parametric coupling with the incident laser radiation. The laser intensity is in the range $10^{12} \leqslant I \leqslant 5 \times 10^{13}$ W/cm^2 focussed on a polyethylene $[(CH_2)_n]$ ribbon 5 mm wide by 125 μm thick by an f/2 off-axis parabola with an angle of incidence of 24° with respect to target normal. The angular distribution of scattered radiation in the specular plane at ω_0 contains two maxima of the same level, one centered at the specular angle and the second centered about 45° from target normal. They are separated by a minimum two orders of magnitude down in energy. This distribution is independent of laser polarisation. The spectral shift is towards the blue in both features and the angular distribution is consistent with Brillouin scattering (not necessarily stimulated) taking into account plasma expansion[1].

The angular distribution of $2\omega_0$ radiation also contains two maxima centered at the same angles as for the scattered ω_0 radiation. The spectral shift is red in the specular and blue for the second maximum at 45°. The red spectral shift is possibly due to coupling of a plasmon produced by parametric decay with an incident laser photon. The blue spectral shift could be due to coupling of a resonance absorption plasmon with an incident photon, plasma expansion producing the observed blue shift. These and other possible mechanisms will be discussed.

(1) G.R. Mitchel et al. Phys. Fluids 25 (1982) 186-192.

POSTER SESSION

TWO-DIMENSIONAL LASER GENERATED SUPRATHERMAL TRANSPORT WITH COLLISIONAL THERMAL RETURN CURRENTS*

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and

D. Besnard

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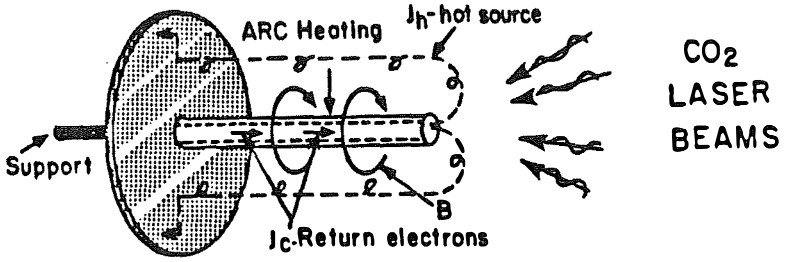
The ANTHEM code has been developed for the study of CO_2 generated electron transport. ANTHEM treats the background plasma as coupled Eulerian thermal and ion fluids, and the suprathermal electrons as either a third fluid or a body of evolving collisional PIC particles. The electrons scatter off the ions; the suprathermals drag against the thermal background. Self-consistent E- and B-fields are computed by the Implicit Moment Method in either x-y or r-z geometry. The current status of the code is described. Typical output from ANTHEM is discussed with special application to the lateral transport of suprathermals to the back of thin foils and shells, and the global behavior of transport in the Augmented-Return-Current CO_2 laser driven targets depicted below.



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

Spatial Distribution of Hot-Electrons in Microwave Plasma Interaction

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Suprathermal electron production by the resonance absorption in microwave plasma interaction experiment is investigated precisely. Two processes are expected to exist in the experiment; the resonance absorption and the parametric decay instability. Both of the processes can produce the suprathermal electrons, but the time dependence of the ejection rate from the resonance layer and the spatial distributions are different in both processes.

Experiments are performed in Ar plasma with linear density gradient, and the microwave is launched from the high gain horn antenna with frequency of 2.45 GHz of up to 2 kW and the maximum pulse length of 8 μsec. Electron distribution function is measured with small plane probe(1 mm x 1 mm) in two dimensional spatially. Hot electrons produced by the resonance absorption process are ejected mainly downward along the density gradient in earier time, while those by the parametric decay instabilitiesare ejected almost 50-60^{o} direction down to the density gradient and delayed from the resonance absorption process by about the instability growth time. The dependence of the hot electron density and temperature on the input microwave power are in good agreement with the theoretical predictions in relation of $n_h \propto p^{0.55}$and $T_h \propto p^{0.36}$, where n_h is the density of hot electron component and T_h is the temperature of that part, although the hot electrons are not thermalized fully not to show the Maxwellian distribution.

F7

Dynamic Acceleration of Electrons in Microwave Plasma Interaction

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and
R.Sugihara
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A new mechanism of producing hot electrons in microwave plasma interaction is proposed to be confirmed experimentally. Obliquely incident p-polarized electromagnetic wave is reflected back at the reflection layer with the density of $n_r = n_c \cos^2\theta$, where $n_c = m_e \omega_o{}^2 / 4\pi e^2$ is the critical density, ω_o is the frequency of incident wave and θ is the icident angle to the density gradient. In larger density side across the reflection layer, electromagnetic wave tunnels into the critical density layer where the electric field becomes resonantly strong and mode converted electrostatic plasma wave is excited. When this plasma wave is strong enouth to trap electrons, the trapped electrons have velocity of about v_{ph}, the phase velocity of plasma wave. If weak magnetic field exists perpendicular to the wave vector, the trapped electrons are suffered $v_{ph} \times B_o$ force. When v_{ph} can be assumed constant, $v_\perp = (v_{ph} B_o / m) t$ and the electron energy increases in proportional to t^2, until $v_\perp \leq c E_o / B_o$, with wave electric field E_o, where electrons are ejected from the wave trough to produce high energy electrons.

The maximun applied magnetic field is about 10G, and the microwave power is less than 2 kW with 2.45 GHz of pulse length up to 8μsec. The suprathermal electorns are observed as a function of magnetic field intensity, and the maximum energy has been confirmed to have $(E_o/B_o)^2$ dependence and a threshold power of microwave.

F8

Some Mechanisms of Hot Electron Preheating Suppression in a Cavity Target

K. Mima, H. Nishimura, H. Daido, S. Nakai and C. Yamanaka

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Osaka University
Osaka, Japan

Hot electron preheating is the most crucial problems in particular for CO_2 laser implosion. Recent experimental results by the CO_2 laser at ILE show that the fast ion and energetic electron spectra in the rear side are softed significantly in a double foil target with a pinhole from which a laser light is injected. The spectra of those energetic particles indicate that the hot electrons more than 60keV seem to be insulated from the rear side of the laser irradiated foil. Those experimental evidences are interpreted by means of electrostatic potential and magnefic field between the accelerated foil and the pingole plate.

According to the previous work1) on the vacuum insulation, the fast ion expansion edge reaches the pinhole plate within 30psec for $T_h \simeq 30$keV and the distance of the double foils, $d \simeq 500\mu m$. Therefore the electric circuit through a low density plasma will be formed early in the laser pulse and the energetic electrons overcoming the potential barrier are removed. Magnetic field generated by the hot electron current will also insulate the energetic electrons from the rear side.

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1) K. Lee et al., Nucl. Fusion, 19, 1447 (1979).

OBSERVATION OF HIGH ENERGY HEAVY ION VELOCITY DISTRIBUTION IN CO_2 LASER-CREATED PLASMAS*

F. Begay, W. Ehler, A. Hauer, S. R. Goldman, and G. R. Magelssen

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Los Alamos, NM 87545

ABSTRACT

Experiments have been performed to investigate the effect of target impurities and surface contamination in the behavior of laser-induced plasmas. Impurities and contamination are removed by heating the target to high temperature prior to the laser shot. In this work we have found that we can produce ion pulses with narrow pulse widths in heated targets. We will present results which characterize the properties of the ion pulses, such as energy flux and ion species type. X-ray data on cold and heated targets will be presented to provide clues on possible physical mechanisms that produce these ion pulses. Also, we will present results on a preliminary feasibility study on the use of these ion pulses in heavy ion fusion. Target performance issues, such as ion energy loss, electron temperature and density, plasma instabilities in the target corona, and preheat, will be considered.

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*Work performed under the auspices of the U. S. Department of Eenrgy.

F11

Fast Ion Spectra from CO_2 Laser Produced Plasmas

S. J. Gitomer, R. D. Jones, F. Begay, A. W. Ehler and J. Kephart

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Measurements of fast ions emitted from laser plasmas produced at the Gemini and Helios CO_2 laser facilities have been made for a wide variety of target materials and focal conditions. Diagnostic devices used in these measurements include (1) Faraday cups, (2) charge cups, (3) filtered calorimeters, and (4) Thomson parabola spectrometers. An analysis of the data has been performed with the aim of determining a fast ion spectrum; namely E dN/dE versus E the energy. We will present the results of the data analysis and comparisons with a number of popular ion expansion models.

SESSION G

Absorption, Transport (Oral)

Wednesday, June 8
8:30 a.m.—12:15 p.m.

R. J. Mason, Chairman
Los Alamos National Laboratory

The Effects of Ion-Acoustic Turbulence on Short Pulse Laser Plasma Interactions

R. Dragila, M.D.J. Burgess, B. Luther-Davies,
K.A. Nugent, A. Perry, G.J. Tallents.

Department of Engineering Physics,
Research School of Physical Sciences,
The Australian National University,
Canberra, A.C.T., 2600, Australia.

We have studied experimentally the density profile and second harmonic light emitted from plasmas generated by short, high intensity Neodymium laser pulses incident upon carbon fibre targets. We observe profile modification in the vicinity of the critical density surface and strong structure in the second harmonic spectrum. The latter is interpreted as indicating the presence of ion waves at the critical surface raising the possibility of that region being turbulent. This deduction is central to the model we use to explain the measurements of the density profile, which is based upon a self-consistent treatment of profile modification due to resonance fields with surface rippling induced by ion-acoustic turbulence to account for the dominance of this mechanism for nominally normally incident laser light. Our model correctly predicts the intensity dependence of the observed profiles and the superthermal electron temperature when the empirically determined intensity dependence of the plasma temperature is included. It is thus consistent with a wide range of observed plasma parameters.

Resonant Absorption At a Sharp Boundary

by

K. B. Quest and J. M. Kindel
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Los Alamos, New Mexico 87545

Resonant absorption of light waves within a density ramp of thickness $L \lesssim c/\omega_{po}$, the collisionless skin depth, is studied. It is shown that the fraction of incident energy absorbed is a sensitive function of the wall dielectric $\varepsilon \equiv 1 - \omega_{pl}^2/\omega^2$, where ω is the frequency of the incident wave, and ω_{pl} the wall plasma frequency. For $\omega_{pl} \gg \omega_{po}$ and $L < c/\omega_{po}$, the fraction of absorbed energy at maximum is shown to be $\simeq 4\pi \left(\frac{\omega L}{c}\right) \frac{\omega^2}{\omega_{po}^2}$. Thus, unless the critical distance $L_c \equiv L \frac{\omega^2}{\omega_{po}^2}$ is $\ll$ than the wavelength c/ω, significant absorption results. When $\omega_{pl} \sim \omega_{po}$, the light wave can tunnel into the wall, resulting in somewhat less absorption for thin layers ($L < c/\omega_{po}$). Results of numerical and simulation studies will be presented.

G3

Abstract Submitted for the Thirteenth Annual Anomalous
Absorption Conference
Banff, Alberta
June 5-10, 1983

INTERACTION PHYSICS IN SPHERICAL GEOMETRY*

M. C. Richardson, J. Delettrez, L. M. Goldman, R. L. Keck, W. Seka,
R. Short, J. M. Soures, K. Tanaka, and E. A. Williams
Laboratory for Laser Energetics
University of Rochester
Rochester, New York 14623

The OMEGA laser facility provides uniform (5% RMS) irradiation of spherical targets permitting quantitative examination of various absorption and interaction processes in a one dimensional configuration. A systematic study of absorption and scattering processes has been made in the interaction of nanosecond, gaussian, 1.05 μm radiation with spherical targets in the intensity range $5 \times 10^{13} - 10^{15}$ W/cm^2. The absorption in this range is expected to change from inverse bremsstrahlung absorption at low intensities to resonance absorption at high intensities. A large array of diagnostics including particle and x-ray spectrometry, calorimetry, and a variety of visible and infrared diagnostics have been utilized to identify and assess the principal absorption mechanisms. We have observed the signatures of the $2\omega_{pe}$ instability at $n_{c/4}$ and resonance absorption and other processes at or near n_c. From this data we have determined the relative partitioning of energy between the various processes. An estimate of the number and temperature of the hot-electrons produced by these processes has also been obtained.

These measurements are compared to results from single beam, 0.35 μm interaction experiments made with the GDL facility, where the $2\omega_{pe}$ and stimulated Raman instabilities were the principal collsionless absorption phenomena. This comparison permits inferences to be made on the relative contributions of these processes to the interaction conditions expected on the OMEGA facility when spherical targets are irradiated symmetrically with nanosecond 0.35 μm laser light at intensities $I \leq 10^{15}$ W/cm^2.

*This work was partially supported by the the U.S. Department of Energy inertial fusion project under contract No. DE-AC08-80DP40124 and by the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics.

Energy Balance in a Laser Gas Jet Experiment

R. Popil, J. Meyer, J.E. Bernard, B. Hilko, H. Houtman, G. McIntosh
University of British Columbia

Inferences about the energy balance in a CO_2 laser gas jet interaction are made based on the x-ray measurements of absorption through foil filters and streak camera measurements of the visible emission. The laser intensities approach 10^{14} W/cm^2 and the target is a 1.3 mm thick supersonic gas jet stabilized in a Helium background atmosphere. The energy balance will be correlated and substantiated by the results obtained from an Ulbricht integrating sphere, the red shift observed in the Brillouin backscatter and by the computations of a one dimensional hydrodynamic computer code simulation.

CLASSICAL HEAT TRANSPORT BY NON MAXWELL-BOLTZMANN ELECTRON DISTRIBUTION*

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University of California, Lawrence Livermore National Laboratory
Livermore, California 94550

Abstract

Non equilibrium electron distributions resulting from anomalous or collisional laser heating relax toward isotropy roughly Z times faster than toward Maxwell-Boltzmann energy distribution. We consider classical electron heat transport in high-Z plasmas where the distribution is dominantly isotropic but not necessarily Maxwell-Boltzmann.

*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

Fluid Modeling of Magnetically Enhanced, Lateral Transport

by

J. U. Brackbill
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Los Alamos, New Mexico 87545

In two recent papers (1, 2), fluid models for electron transport in self-generated magnetic fields are described. The models incorporate the Braginskii transport equations (3) for massless electrons and unmagnetized ions. They have been used to estimate the importance of guiding center correction terms (2), to develop appropriate flux limits for the transport terms (1), and to guide modifications to existing design codes to include the magnetic field effects observed in plasma simulations (4).

Here we present the results of further studies that address the dependence on the incident laser wavelength of magnetically enhanced transport, and on CO_2 laser targets in cylindrical geometry.

Although magnetic effects have been reported principally for CO_2 laser targets (5), we observe in our calculations that magnetic fields also cause convective electron energy transport at other wavelengths for sufficiently localized deposition and sharp density gradients. We find, however, that resistive diffusion limits the range of propagation of the magnetized sheath, and thus the range of convective electron transport. Quantitative estimates of the range in experiments require more exact characterization of the properties of the target surface than are incorporated in the model.

1. J.U. Brackbill and S.R. Goldman, "Magnetohydrodynamics in Laser Fusion: Fluid Modeling of Energy Transport in Laser Targets," sub. to Comm. Pure and Appl. Math.

2. J.U. Brackbill, D.Colombant and N. Grandjouan, "Convective Transport in Laser Target Plasmas," 1982 CECAM Workshop Proceedings.

3. S.I. Braginskii, Reviews of Plasma Physics 1 (1965) 205.

4. D.W. Forslund and J.U. Brackbill, Phys. Rev. Lett. 48 (1982) 1634.

5. M.A. Yates et al, Phys. Rev. Lett 49 (1982) 1702; J.C. Kieffer et al, Phys. Rev. Lett 50 (1983) 1054.

INTERPRETATION OF RECENT THERMAL AND SUPRATHERMAL TRANSPORT EXPERIMENTS

W. B. Fechner and J. T. Larsen
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ABSTRACT

Recent experiments from spherical transport experiments at KMS have been analyzed with the one-dimensional spherical simulation code. Simulation results show the radial energy transport via electron conduction to be inhibited relative to classical values. There is also a strong indication that the suprathermal population, for λ_L 1.05 μm, is inhibited. A comparison of results from calculations for a selected set of experiments will be discussed in light of different diffusion models.

ANALYSIS OF THERMAL TRANSPORT EXPERIMENTS AND THEIR IMPLICATION OF A THRESHOLD FOR TRANSPORT INHIBITION

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Lawrence Livermore National Laboratory
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ABSTRACT

We present LASNEX simulations of the layered sphere, electron transport experiments performed at both KMS and URLLE. Our results[1] are in basic agreement with the analyses done at each of those labs using TRHYD and LILAC respectively[2,3].

Observables to be discussed include CH burn-thru times ("m"),[4,5] density profiles,[6] absorption fractions, and hard x-ray spectra.

When plotting the mass ablation rate, m, vs absorbed intensity, we find most data below I_a mid 10^{13} W/cm^2 falling on a curve generated by LASNEX using an f = 0.5 flux limiter. Above that intensity value, the data fall mostly on an f = 0.03 curve. This suggests an Intensity Threshold for transport inhibition in this range (for plastic). We remind the audience of previous indications of such a threshold.[7,8,9].

*Work Supported by U.S.D.O.E., contract #W-7405-ENG-48.

1. M. D. Rosen, "Proceedings of the URLLE Transport Workshop," January, 1983. Vol. II.

2. W. Fechner, ibid.

3. J. Delettrez, ibid.

4. J. A. Tarvin, et al. ibid, Vol. I.

5. B. Yaakobi, et al., ibid.

6. M. D. Rosen, G. Busch, G. Charatis, & C. Shepard, Bull. Am. Phys. Soc. 27, 989 (1982).

7. J. Pearlman & J. Anthes, Appl. Phys. Lett. 27, 581 (1975).

8. G. McClellan, et. al., Phys. Rev. Lett. 44, 658 (1980).

9. S. Witkowski, et. al. "9th International Conference on Plasma Physics and Controlled Nuclear Fusion Research," Baltimore, September 1982.

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Abstract Submitted for the Thirteenth Annual Anomalous

Absorption Conference

Banff, Alberta

June 5-10, 1983

THE EFFECT OF THERMAL FLUX SATURATION ON LATERAL HEAT TRANSPORT - A MULTI-GROUP ANALYSIS*

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Lateral heat transport can play an important role in smoothing nonuniformities in laser energy deposition for laser-driven fusion. When the heat flow becomes saturated (flux-limited) the amount of thermal smoothing can deviate considerably from classical estimates. Classically, a temperature nonuniformity of wave number k will be attenuated as $\exp(-k\Delta R)$ over a distance ΔR. For saturated transport, the usual expression for flux, $q \sim fnT^{3/2}$, yields an attenuation that varies exponentially as the *square* of the wave number, $\exp(-Lk^2\Delta R)$, where L is the temperature scale length. This result assumes that electrons carrying most of the heat have mean-free-paths small compared to the local temperature scale length. However, recent calculations have shown that these electrons can have relatively long mean-free-paths at laser fusion conditions, producing a non-Maxwellian energy distribution. The *non-local* electron transport produces, in a natural way, the effect of flux inhibition, and this process must be considered in the calculation of lateral heat transport.

To examine this effect on thermal smoothing we consider a model problem for non-local heat transport. The Krook, multi-group electron transport equation is solved in the diffusion approximation for the normal direction, using a self-consistent electric field to obtain the heat flow and electron distribution function. The equations are then linearized to find the attenuation of a transverse temperature perturbation.

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*This work is supported by the sponsors and participants of the Laser Fusion Feasibility Project of the Laboratory for Laser Energetics.

Abstract Submitted for the Thirteenth Annual Anomalous
Absorption Conference
Banff, Alberta
June 5-10, 1983

SIMULATION OF TRANSPORT EXPERIMENTS AT LLE USING NON-LOCAL ELECTRON TRANSPORT MODELS*

J. Delettrez, S. Skupsky, D. Shvarts[a], and R. L. McCrory
Laboratory for Laser Energetics
University of Rochester
Rochester, New York 14623

Burnthrough experiments carried out last year at LLE on uniformely illuminated microballoons yielded unexpected results: The burnthrough depth in plastic over an aluminum substrate was about twice as large as that observed in flat target experiments and the burnthrough depth to a titanium substrate was about half that obtained for an aluminum substrate (burnthrough is determined by x-ray emission from the substrate). Simulation with the code LILAC using the usual flux-limited thermal diffusion transport model could reproduce the burnthrough depth for the titanium substrate but not the burnthrough depth for the aluminum substrate. These results indicate that the heat front has either a long "warm" foot preceding it or is not as steep as that expected from classical theory. During that period it was realized that the thermal electron transport in the presence of steep temperature gradients could not be modeled using Spitzer's conductivity because of the long mean-free-path of the electrons carrying most of the energy[1]. Since these electrons deposit their energy ahead of the main heat front, they can create a preheat foot.

Non-local heat transport models have been developed to study the thermal electron transport in laser fusion targets. They include multi-group diffusion and self-consistent electric fields. Results for cathode problems are compared with those obtained with a Fokker-Planck code[2]. Simulations of the burnthrough experiments are presented including a discussion of the electron distribution function in the substrate and a comparison with local transport models of the shape and penetration of the heat front.

(a) Nuclear Research Centre, Negev, Israel.

1. A. R. Bell, R. G. Evans and D. J. Nicholas, Phys. Rev. Lett. 46, 243 (1981); D. Shvarts, J. Delettrez, R. L. McCrory, and C. P. Verdon, Phys. Rev. Lett. 47, 247 (1981).
2. J. P. Matte and J. Virmont, Phys. Rev. Lett. 49, 1936 (1982).

*This work is supported by the U.S. Department of Energy inertial fusion project under contract No. DE-AC08-80DP40124.

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Abstract Submitted for the Thirteenth Annual Anomalous

Absorption Conference

Banff, Alberta

June 5-10, 1983

SPECTRAL SIGNATURES OF NON-MAXWELLIAN AND NON-LTE EFFECTS IN THERMAL TRANSPORT EXPERIMENTS*

R. Epstein, S. Skupsky and B. Yaakobi
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University of Rochester
Rochester, New York 14623

Recent thermal transport experiments have used the emission spectra of highly ionized atoms to signal the advance of laser-driven heat fronts. The usual assumption of local thermal electron transport has been regarded as a possible source of discrepancy and uncertainty in the interpretation of these experiments. Deviation from a Maxwellian electron energy spectrum is expected and can significantly alter the degree of ionization and the intensity of spectral lines. We calculate these effects for modified Maxwellian distributions where these electrons are described predominantly by a cold temperature of less than a few hundred eV, with a small multi-keV "tail". Modified transition rates are calculated to determine under what conditions and on what time scales small changes in electron distributions at high energies can significantly modify the emission spectra of highly ionized atoms.

*This work is supported by the sponsors and participants of the Laser Fusion Feasibility Project of the Laboratory for Laser Energetics.

Abstract for the 13th Annual Anomalous Absorption Conference

HEAT FLUX LIMITATION DUE TO HOT ELECTRONS*

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ABSTRACT

The analysis of Shkarofsky[1] is extended to include a variable degree of collisionality. This analysis, with hot suprathermal electrons in addition to thermal electrons, shows that heat inhibition can occur in laser-fusion experiments in the coronal region. The hot electrons can cause the flux limiter to decrease substantially below the free-streaming limit in an intermediate range of collisionality. We adopt a Maxwellian disbribution for the hot electrons, but compare a Maxwellian to an $\exp(-v^5/v_c{}^5)$ variation[2] for the cold electrons and find that the flux limiter decreases more for the latter case. A variable degree of collisionality is treated using a modified version of the method of Shvarts et al[3] in which the perturbed electron velocity distribution is limited in magnitude to the unperturbed part when the former becomes larger than the latter.

1. I.P. Shkarofsky, Phys. Rev. Lett. 42, 1342 (1979).
2. A.B. Langdon, Phys. Rev. Lett. 44, 575 (1980).
3. D. Shvarts et al, Phys. Rev. Lett. 47, 247 (1981).

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* Work supported by the U.S. Department of Energy under contract DE-AC08-81DP40162.

Solution of the time-independent Vlasov-Fokker-Planck equation for a planar ablating plasma

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The time-independent Vlasov-Fokker-Planck equation for collisional electrons has been solved numerically in the approximation that 1) the electron distribution function is expressed as $f(v,v_x) = f_0(v) + f_1(v)v_x/v$ 2) the collision operator takes its asymptotic high-velocity form. The equation has been solved self-consistently with the cold-ion fluid equations and used to model the ablation of a planar laser-produced plasma. The resulting temperature and density spatial profiles do not differ greatly from those calculated from the Spitzer conductivity.

SESSION H

Invited Review on Electron Thermal Transport

T. J. M. BOYD
University College of North Wales

Wednesday, June 8
6:30 p.m.—7:30 p.m.

Discussion
7:30 p.m.—8:00 p.m.

T. W. Johnston, Discussion Leader
INRS—Energie

SESSION I

Absorption, Transport (poster)

Wednesday, June 8
8:00 p.m.—11:00 p.m.

ON THE USE OF X-RAY RADIATION TO DIAGNOSE LASER PLASMAS BY REFRACTOMETRY

R. BENATTAR

Laboratorie de PMI - Ecole - Polytechnique

97728 Palaiseau - cedex - France

ABSTRACT

Time-Dependent X-ray Spectra
From Laser-Produced Plasmas

R. L. Kauffman, D. L. Matthews, R. W. Lee,
and B. Whitten

Lawrence Livermore National Laboratory
Livermore, California

April 1, 1983

We have measured x-ray spectra from laser-produced plasmas using high-resolution x-ray spectrographs. Both time-resolved and time-integrated data are obtained. Most of the data are of L emission spectra for elements from Cr to Ni produced by 100 ps irradiation at intensities from 5×10^{13} - 3×10^{14} W/cm^2 by 0.532 μm light. The spectra are dominated by Ne-like through Li-like ionization states. Preliminary analysis will be presented on spectral analysis in term of plasmon density and temperature. Relation of these parameters to the laser-plasma physics will be discussed.

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Multi-Photon Ionization in Laser-Plasma Simulations

J.N. McMullin and C.E. Capjack, University of Alberta

The threshold laser flux for multi-photon ionization (MPI) is approximately

$$F_{MPI} = 1.5cN_{cr}I = 8\times10^{12}\ I(eV)/\lambda^{2}(\mu)\ W/cm$$

where I(eV) is the ionization potential in eV and $\lambda(\mu)$ is the laser wavelength in microns. The MPI absorption rate varies rapidly with the laser flux F (e.g., $(F/F_{MPI})^{115}$ for CO_2 light in oxygen) so that accurate modelling of the process would be extremely difficult. The importance of MPI, however, is in providing large numbers of seed electrons at the correct time in the experiment after which collisional ionization dominates. With this in mind, an approximate MPI scheme has been devised which instantly ionizes the plasma when the laser flux crosses the threshold. The degree of ionization achieved depends on the amount of energy at super-threshold levels the laser can deliver to a cell in the current hydrodynamic timestep. The MPI routine works in conjunction with the laser propagation routine so that local decreases in laser flux due to MPI can affect the subsequent beam behaviour. Results of a simulation of a CO_2 laser on O_2 gas target experiment at the U. of Alberta will be presented as a demonstration.

A CONSERVATIVE ELECTRON FOKKER-PLANCK (LANDAU) CODE

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The Fokker-Planck equation for electrons,

$$\frac{\partial f}{\partial t} + \ldots = C_{ee}(f,f) \ ,$$

is approximated by the first two angular moments, assuming $f_o \gg \vec{f}_1 \gg \overline{\overline{f}}_2 \ \ldots$:

$$\partial f_o/\partial t + \ldots = C^o(f_o,f_o) \quad , \quad \partial \vec{f}_1/\partial t + \ldots = C^1(f_o,\vec{f}_1) \quad ,$$

and discretized on N velocity points. The following properties of Landau's collision operator C_{ee} could be kept exact at the discrete level (i.e. with integrals replaced by finite sums, etc.).

(a) Conservation of density, momentum and energy /1/ :

$$\int v^2 dv\ C^o = 0 \quad , \quad \int v^4 dv\ C^o = 0 \quad , \quad \int v^3 dv\ C^1 = \vec{0} \ .$$

(b) Galilean invariance to first order:

$$C^1(f_o,\ \vec{f}_1 + \vec{\delta u}\ \partial f_o/\partial v) = C^1(f_o,\vec{f}_1) + \vec{\delta u}\ \partial C^o(f_o,f_o)/\partial v \ .$$

(c) Maxwellian equilibrium with any n and any T /2/ :

$$C^o(f_M,f_M) = 0 \quad , \quad f_M = n\ (2\pi T)^{-3/2} \exp(-mv^2/2T) \ .$$

(d) Onsager's reciprocity relations. Linearizing near equilibrium,

$$f = f_M + \Delta f \quad , \quad C_{ee}(f,f) \simeq C_L(f_M,\Delta f) \quad ,$$

$$\int v^2 dv\ (\Delta' f_o/f_M)\ C_L^o(f_M,\Delta f_o) = (\Delta \rightleftarrows \Delta') \quad ,$$

$$\int v^2 dv\ (\overrightarrow{\Delta' f_1}/f_M).C^1(f_M,\overrightarrow{\Delta f_1}) = (\Delta \rightleftarrows \Delta') \ .$$

Moreover, these properties could be made exact (up to the accuracy of the computer) for any N , with a slight modification of /1,2/ at the end point. Even N = 2 has a meaning, the equations reducing to those of hydrodynamics plus an equation of evolution for the heat flux : $\partial \vec{q}/\partial t = \ldots$

2 N quantities v_i and dv_i are still free; one can consider a Gauss-Hermite (or -Laguerre) integration scheme. A Gauss-Hermite scheme varying in space and time, with fixed points $w = |\vec{v} - \vec{u}|\sqrt{m/T}$, has additional advantages.

/1/ A. Bruce Langdon, Report of CECAM Workshop on "the flux limiter and heat flow instabilities in laser-fusion plasmas", Orsay (1981), p.69 .
/2/ J.S.Chang and G.Cooper, J.Comput.Phys. 6 , 1 (1970).

FLUX LIMITED TRANSPORT COEFFICIENTS IN PLASMAS WITH STEEP GRADIENTS

P. M. Campbell and J. T. Larsen
KMS Fusion, Inc., Ann Arbor, MI 48106

ABSTRACT

The classical transport coefficients of Spitzer and Härm are based on a first-order Chapman-Enskog expansion of the distribution function which is known to fail in steep gradients. The traditional fix is to limit the diffusion expression for the heat flux to the value for free streaming particles in a neutral gas, $q_L = f_c\, n_e kT(kT/m)^{1/2}$. No precise derivation of the classical flux limit has heretofore been available, but f_c as determined by various heuristic arguments lies in the range $0.2 < f_c < 1$. This is an order of magnitude larger than the values generally found necessary to match laser plasma experiments.

The objective of the present work is to develop a computational method which leads to a rigorously defined flux limit for electron transport coefficients. A method originally developed for radiative transfer is used to obtain a solution to the Boltzmann equation which goes over from the classical diffusion form at low energies to the streaming form at energies for which the electron mean free path exceeds the scale length. The method is developed in the present paper for a Lorentz gas and extended, provisionally, to S-H thermal conductivity.

Collisional Aspects of Suprathermal Transport in CO$_2$ Laser Target Interactions*

S.R.Goldman, J.U.Brackbill, D.W.Forslund, A.A.Hauer, R.Mason, and M.Mueller
Los Alamos National Laboratory

A number of significant features of CO$_2$ laser-target interactions involve the interplay of particle collisions with largely collisionless coronal transport. For example, in competition with magnetic field generation, collisions can control deposition as a function of distance from the laser spot center even for targets whose thickness is less than the suprathermal range.[1] In addition, collisions can reduce the anisotropy of the electron distribution function in the corona, thereby affecting the subsequent transport and deposition within the target. As a first step towards understanding such behavior, we report results from a simple model of electron scattering within the implicit particle VENUS code.[2,3]

1.A. Hauer et al., submitted to the Sixth International Workshop on Laser Interaction and Related Plasma Phenomena, Monterey,Ca.
2.D.W.Forslund and J.U.Brackbill, Phys. Rev. Lett. 48, 1614 (1982)
3.J.U.Brackbill and D.W.Forslund, J. Comput. Phys. 46, 271 (1982)

*Work performed under the auspices of the U. S. Department of Energy.

SESSION J

Hydrodynamics (oral)

Thursday, June 9
8:30 a.m.—12:15 p.m.

M. C. Richardson, Chairman
Laboratory for Laser Energetics
University of Rochester

13th Annual Anomalous Absorption Conference
Alberta, Canada (June 5-10, 1983)

DIRECTIONS OF NRL RESEARCH*

S.E. Bodner, D. Colombant, M.H. Emery, J.H. Gardner, J. Grun,(a)
M.J. Herbst, S. Kacenjar, K. Kim, R.H. Lehmberg, W. Manheimer, E.A. McLean,
S.P. Obenschain, B.H. Ripin, J.A. Stamper, R.R. Whitlock and F.C. Young

Until recently, the NRL laser fusion program has emphasized near-IR laser wavelengths for direct-drive in order to provide enough thermal smoothing of laser nonuniformities, plus broad bandwidth to control plasma instabilities. Unfortunately, near-IR lasers produce a marginal overall coupling efficiency. Near-UV lasers would provide a better coupling efficiency, but then the smoothing of laser nonuniformities is questionable, although still uncertain. There has also been a proposal to shift the laser frequency during the pulse, starting with near-IR and ending with near-UV, but to-date there has not been enough detail provided on this hybrid to evaluate the net smoothing and net efficiency.

We[1] are proposing a new concept, called Induced Spatial Incoherence, that offers the potential of ultra-uniform illumination of targets starting with realistic laser beam quality. This may then give us the best of both worlds: good coupling efficiency and uniform illumination with a near-UV laser. We will discuss some of the relevant hydrodynamics and laser-plasma coupling physics issues, and the role of this new concept in the future NRL program.

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1. R.H. Lehmberg and S.P. Obenschain, Optics Comm. (to be published).

* Work supported by U.S. Department of Energy and Office of Naval Research.

(a) Mission Research Corporation.

BROAD-BAND LASER-TARGET INTERACTION*

S.P. Obenschain, J. Grun,(a) M.J. Herbst, K. Kearney,(a) E.A. McLean,
N.E. Nocerino,(b) J.A. Stamper, R.R. Whitlock, F.C. Young, S.E. Bodner,
S. Kacenjar, K. Kim, J. Kosakowski,(b) R.H. Lehmberg and B.H. Ripin

Naval Research Laboratory, Washington, DC 20375

Finite-laser-bandwidth has been proposed as a means to control parametric instabilities occurring in laser-plasma interactions. A new application for laser bandwidth utilizes spatial incoherence of a laser to achieve ultra uniform illumination of targets. This spatial incoherence can be simply achieved by placing differential delays across a laser beam that has a short temporal coherence.[1,2] The technique may require laser bandwidths of only a few tenths of a percent.

We have begun studies of the feasibility of using this irradiation smoothing technique; including experimentation on the effects of moderate laser bandwidths on laser-target interaction. We present here measurements of the absorption and x-ray generation obtained with a variable-bandwidth glass laser. Four nsec laser pulses were focused onto planar targets with typical laser energies and irradiances of 100 J and 10^{14} W/cm^2 respectively. By using tunable glass and ND-YLF oscillators, the laser spectrum could be adjusted from the time-bandwidth limited case to bandwidths up to 0.3%. The bulk of the studies involved the use of laser pulses with a continuous spectral distribution produced by random amplitude modulation. At bandwidths above 0.1%, we observed increased absorption and increased hot electron temperature. We will discuss the relevance of these studies to using spatial incoherence for laser smoothing and the control of instabilities which may be enhanced by laser bandwidth.

---

[1] R.H. Lehmberg and S.P. Obenschain, Optics Communications (to be published).
[2] S.P. Obenschain and R.H. Lehmberg, CLEO Conference, Baltimore, MD (1983).

*Work supported by the U.S. Department of Energy and Office of Naval Research.
(a) Mission Research Corporation
(b) Sachs-Freeman Associates

Improvement of Irrdiation Uniformity by Random Phase Mask

K. Mima, Y. Kato and C. Yamanaka

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Osaka University
Osaka, Japan

In laser fusion, spatial and temporal coherence property of the laser light is used to advantage for focusing the laser beam to a small spot on a small fusion target with the well-controlled temporal profile. Because of the spatial coherence, however, small aberation of a fraction of a wavelength as well as the intensity nonuniformity of the incident laser beam results in large intensity nonuniformity on the target which might exceed tolerance limit for symmetrically imploding the fusion target. Also the spatial and temporal coherence induces nonlinear phenomena in the laser plasma, such as filamentation instability, stimulated scattering and so on.

The random phase mask reduces spatial coherence of the laser beam resulting in uniform irradiance distribution on a target. The small scale irradiance fluctuations associated with the random phase will be smoothed out by the dispersive effect of plasmas. In addition, various plasma instabilities are suppressed due to the wide spatial frequency bandwidth and the phase randomness. Theoretical analysis of the growth rate of the filamentation instability and the parametric instabilities under spatially incoherent laser pumping is presented.

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13^{TH} ANNUAL ANOMALOUS ABSORPTION CONFERENCE
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June 5-10, 1983

OBSERVATION OF SPACE-RESOLVED NON-UNIFORMITIES AND ENERGY SMOOTHING EFFECTS ON PLANE TARGETS AT 0.35 μM LASER IRRADIATION

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In order to achieve high target densities-high velocities required in the inertial confinement context, a particular attention must be paid to three among a number of distinct physical processes, i.e. the preheat level, the stability and the symmetry of the target. It has been widely suggested that electronic preheat level is reduced by the use of short laser wavelengths. In this paper, we consider the target asymmetries arising from imposed non-uniformities on laser intensity and target structure.

The hydrodynamic behavior of thin Al and Au disk targets irradiated with a 1 nsec frequency-tripled Nd-laser pulse is experimentally studied at irradiances ranging from 10^{13} W cm^{-2} to 10^{14} W cm^{-2}. A space-resolved X-ray backlighting diagnosis has been developped to measure the asymmetry of the target velocity versus the inhomogeneity scale length, $\lambda_{i\ell}$, for different target material (Al, Au) and laser irradiance I.

Target velocity non-uniformity is expected to decrease with decreasing $\lambda_{i\ell}$ and increasing I. Furthermore, smoothing improvement is observed with layered targets, for instance, a gold layer onto a thin aluminum foil. This result is discussed in terms of radiation transfer from the high Z layer.

2-D Lasnex Ray Trace Studies of Thermal Self Focusing in Cylindrical Geometry

Kent Estabrook and W. L. Kruer

University of California
Lawrence Livermore National Laboratory, Livermore, CA 94550

We use 2-D r-z cylindrical symetry Lasnex simulations to examine the competition between thermal self-focusing and inverse bremsstrahlung absorption in large regions of hydrogen and gold plasmas with an initially constant density and temperature. For parallel ray, fairly strong pumps and low initial temperatures, we find that the light self focuses to about an order of magnitude greater intensity than incident and that the rays tend to bounce along the center line forming beads of concentrated light. We find, for similar conditions, that diverging rays from an f4 lens do not self focus. We compare our results to the theory reported in Herbst[1] et al. of NRL.

1. M. J. Herbst, J. A. Stamper, R. H. Lehmberg, R. R. Whitlock, F. C. Young, J. Grun, and B. H. Ripin, Proceedings of the 1981 Topical Conference of Symetry Aspects of Inertial Implosions, ed. S. Bodner.

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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.

Abstract Submitted for the Thirteenth Annual Anomalous

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HYDRODYNAMIC CALCULATIONS OF THERMAL SELF-FOCUSING IN LASER PLASMAS*

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Laboratory for Laser Energetics
Rochester, New York 14623

The two-dimensional Eulerian hydrodynamic code SAGE has been used to examine the effects of nonuniform irradiation on plasmas with long scale-lengths, including a fully self-consistent ray-tracing model. In particular, thermal self-focusing is investigated in a variety of situations which illustrate the interrelationship of the hydrodynamics, refraction and thermal diffusion processes. Enhancement of perturbations through thermal self-focusing requires (at least) that the underdense plasma scalelength is sufficient to ensure the refraction of rays through transverse distances comparable with the transverse inhomogeneity scale-length, as might be expected. Results from representative cases will be presented.

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*This work was partially supported by the U.S. Department of Energy Inertial Fusion Project under contract number DE-AC08-80DP40124 and by the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics.

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13th Annual Anomalous Absorption Conference
Alberta, Canada (June 5-10, 1983)

Interactions of a Laser-Produced Plasma with a Magnetized Background Plasma*

B.H. Ripin, J. Grun,[a] M.J. Herbst, S.T. Kacenjar,[b]
K.J. Kearney,[a] E.A. McLean, S.P. Obenschain, J.A. Stamper,
F.C. Young, J.D. Huba, and R.A. Smith[c]

Naval Research Laboratory, Washington, DC 20375

Low-density plasma streaming instabilities can be studied experimentally using laser-produced plasmas.[1] The instabilities arise from the interaction ~~of counter streaming ion~~ -ion or electron-ion distribution functions transverse to a magnetic field in a parameter regime where the plasma beta is high and the streaming velocities are super-Alfvenic.[2] The laser-produced plasma from an initially solid target, irradiated by a 4-nsec, 200 J Nd-laser pulse, expands with a net drift velocity of ~ 7×10^7 cm/sec through a stationary ambient plasma; the ambient plasma is produced by photoionizing the background gas with the radiation from the laser-target interaction. The ambient plasma is magnetized with an externally applied magnetic field of 700 G or, in some cases, is left unmagnetized excepting for self-generated fields.

In this paper we will describe our initial experiments designed to examine interactions between the drifting and stationary plasmas and map out the expected coupling regions. In a search for the magnetized ion-ion stability,[3] carbon targets and low pressure (~ 15 mTorr) hydrogen background gas were used. We have made observations of the interaction through measurements of the expanding plasma velocity distributions, magnetic field compression and self-generation, light emission from the photoionized plasma (before and during the interaction) and x-ray emission. Also optical probe beam and tracer dot techniques have been applied to the problem.

We will summarize experimental findings and discuss their interpretation.

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* Work supported by the Defense Nuclear Agency.

[a] Mission Research Corporation, Alexandria, VA.

[b] NRL-NRC Postdoctoral Research Associate.

[c] Science Applications Inc., McLean, VA.

[1] B.H. Ripin, J. Grun, M.J. Herbst, S.T. Kacenjar, C.K. Manka, E.A. McLean, S.P. Obenschain, and J.A. Stamper, Bull. Am. Phys. Soc. 27, 1041 (1982).

[2] M. Lampe, W.M. Manheimer, and K. Papadapoulos, NRL Memo #3076 (1975).

[3] R.A. Smith and J.D. Huba, to be published.

J8

13th Annual Anomalous Absorption Conference
Alberta, Canada (June 5-10, 1983)

Experiments on the Rayleigh-Taylor Instability of Ablatively Accelerated Targets Using Face-on X-ray Backlighting[+]

J. Grun,[a] M. Emery, M.J. Herbst, S. Kacenjar, E.A. McLean,
S.P. Obenschain, B.H. Ripin, and M. Fink[b]

U.S. Naval Research Laboratory, Washington, DC 20375

The Rayleigh-Taylor instability in an ablatively accelerated target causes mass to flow laterally from the thinner to the thicker parts of the target. Consequently, measurements of areal mass across the target surface at a known time into the laser pulse, or measurements of the rate-of-change of areal mass density, can be related to the instability growth rate.

We describe measurements on ablatively accelerated targets which have a periodically perturbed areal mass density to provide initial conditions for instability growth. The measurements are made using a face-on x-ray backlighting method that does not require a separate backlighting x-ray source or a separate backlighting laser beam. Instead, the higher-Z backlighting x-ray source is incorporated into a lower-Z target and the backlighting and driver laser beams are identical.[1] In our experiments, the x-ray source is a thin layer of magnesium that is buried inside a carbon or a carbon/parylene target with 25 μm to 100 μm perturbation period and a 1 to 1.6 perturbation amplitude (thick/thin). The laser beam (1.05 μm, 1 x 10^{13} W/cm^2, 5 nsec FWHM) accelerates this target to 100 km/sec, all the while ablating its low-Z surface but producing relatively few (> 1 Kev) x rays. Once the low-Z target layer is depleted - and hopefully the instability well developed - the thin magnesium layer heats up emitting a short burst of > 1 Kev x rays that are used to radiograph the target.

Also to be discussed is the use of laterally offset magnesium layers buried at varying depth in the target to temporally and spatially resolve the evolution of areal mass perturbations.

[+] Sponsored by the U.S. Department of Energy and the Office of Naval Research.

[a] Mission Research Corporation

[b] Sachs/Freeman Associates

[1] J. Grun et al., NRL Memorandum 4896 (1983).

Analytic Models for Rayleigh Taylor Stabilization by Smoothe Density Profile, Vortex Shedding, Slab Compressibility, Thermal Conduction and Ablation

Wallace M. Manheimer and Denis G. Colombant
Plasma Physics Division
Naval Research Laboratory

The Rayleigh-Taylor Instability is of crucial concern for laser fusion, and as such has been intensively studied, principally by fluid simulation.[1,2] The general conclusion is that the linear growth rate is reduced from the classic $\gamma = \sqrt{kg}$ by about a factor of two for the most important k, and by more for larger k's. To provide some analytic insight into these results and also to provide scaling laws for extension into other regions of parameter space, we have performed theoretical work using simpler models. One advantage of this approach is that it gives results over the entire range of parameter space relevant to laser fusion.

In our analysis, two effects were investigated separately, the effect of density profile, and the effect of flow through the ablation surface. For the former, we utilized steady state density profile from our model of steady planar ablation flow,[3] and assumed incompressible flow everywhere. The result is that for kX_o (X_o = slab width) < 1, there is a reduction in growth rate by about a factor of two, in rough agreement with fluid simulations. However for larger kX_o, there is virtually no reduction in γ.

To analyze the effect of flow through the ablation layer, we have used a slab model and have solved the problem by conserving mass, momentum and energy across the moving interface. The result is that the large kX_o modes are now stabilized by flow through the interface. One interesting additional result is that the relative reduction of growth rate is nearly independent of all physical parameters of the system.

1. C. P. Verdon, et al, Phys. Fluids 25, 1653 (1982).
2. M. H. Emery, J. H. Gardner and J. P. Boris, Phys. Rev. Lett. 48, 677 (1982).
3. W. M. Manheimer, D. G. Colombant and J. H. Gardner, Phys. Fluids, 1644 (1982).

U-1342ab

THEORETICAL ASPECTS OF THE PLASMA EVOLUTION FROM GOLD DISKS

R. R. Johnson, C. L. Shepard, Gar. E. Busch
KMS Fusion, Inc.
P.O. Box 1567
Ann Arbor, MI 48106
(313)769-8500

The time-resolved plasma density profiles obtained during various stages of plasma evolution from gold disks are analyzed theoretically. The plasma densities probed ranged from 10^{19} - 6×10^{20} electrons/cm^3. Plasma scalelengths varied from 10 μm at early probe times to 80 μm in this set of experiments. The measured plasma expansion velocity and scalelengths are compared to calculations in order to determine the amount of thermal flux limitations required. Additional information obtained from these experiments makes possible a determination of the relationship between lateral and radial heat flow in disk targets irradiated with 0.5 μm laser light.

13th Annual Anomalous Absorption Conference
Alberta, Canada (June 5-10, 1983)

Vortex Shedding, Magnetic Fields and Flux Inhibition*

Mark H. Emery, John H. Gardner and Jay P. Boris
Naval Research Laboratory
Washington, DC 20375

An investigation of laser ablatively accelerated targets using our two-dimensional laser-matter interaction code, FAST2D, shows strong vortex structures and, equivalently, magnetic fields generated at and subsequently shed from the ablation layer whenever the density and pressure profiles become non-collinear. The non-collinearity can be produced by perturbations in the target profile itself or by asymmetries in the laser profile. The vortex shedding process creates a von Karman vortex street which extends from the ablation layer to the underdense region. The fact that vortices and magnetic fields fill the region between the ablation surface and the underdense region raises serious questions concerning laser absorption processes, back-scatter, self-focusing, plasma instabilities and turbulence in the underdense region and thermal flux-inhibition. We have previously shown that the vortex shedding process is the cause of the inhibited linear Rayleigh-Taylor growth and the short wavelength cutoff+.

Here we present the results of a series of calculations for several target parameters and laser wavelengths in investigating the magnetic field structures generated by moderately sized laser asymmetries and the effect of those fields on thermal flux inhibition. We find multimegagauss fields are generated at the ablation layer. These fields have a resistive decay time on the order of 4 times longer than the 3.5ns laser pulse and fall off as $\sim r^{-1}$ away from the ablation layer reaching values in the tens of kilogauss range at the critical surface. These magnetic fields fill the overdense region and give rise to thermal flux inhibition factors comparable to those invoked to explain experimental results.

*Work supported by U.S. Department of Energy and Office of Naval Research.

+M.H. Emery et al., Proc. of 9th International Conference on Plasma Physics and Cont. Nuc. Fus. Res., Baltimore 1982.

J13

A New Shock Wave and Its Application to Inertial Confinement Fusion*

by

B. Bezzerides, R. D. Jones, J. Saltzman, and C.H. Aldrich
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

Recent numerical simulations have revealed the existence of a very narrow magnetic rarefaction shock wave. The thickness of this shock is on the order of c/ω_{pe} The simulations indicate that this structure is very general and occurs whenever surfaces are strongly heated (as in most inertial confinement fusion schemes). This rarefaction shock is important to ICF because:
1) the structure can be created on the surface of an ion diode to accelerate driver ions,
2) the magnetic fields of the structure can be used to implode pellets directly, and
3) the structure enhances decoupling and fast ion energy loss in traditional targets.

We present here results of the first detailed calculations on the conditions for the existence of the shock. The structure, the shock, and its effect on the acceleration of ions will also be discussed.

*Work performed under the auspices of the U.S. Department of Energy.

SESSION K

Invited Review on Radiative Transport

K. WHITNEY
Naval Research Laboratory

Thursday, June 9
6:30 p.m.—7:30 p.m.

Discussion
7:30 p.m.—8:00 p.m.

D. Attwood, Discussion Leader
Lawrence Livermore National Laboratory

ABSTRACT

ENERGY TRANSPORT BY RADIATION

K. G. Whitney

A review will be given of the mechanisms by which X-radiation is generated, propagated, and absorbed in hot, dense micro-plasmas, where X-ray absorption lengths and the dimensions over which plasma temperatures and densities vary are comparable. First, some comparisons between the problems of electron and photon transport will be made. Then, a detailed description of the physical properties of the photon transport equation will be given using aluminum or argon to illustrate the behavior of X-ray source functions, absorption lengths, and energy fluences as a function of plasma conditions. Comparisons will also be made between LTE and non-LTE behavior.

SESSION L

Hydrodynamics (poster)

Thursday, June 9
8:00 p.m.—11:00 p.m.

ABSTRACT

0.53 μm Interaction Experiments With Long Scalelength Plasmas

R. E. Turner, R. P. Drake, D. W. Phillion, F. Ze,
E. M. Campbell, K. Estabrook, B. L. Lasinski, W. C. Mead

Lawrence Livermore National Laboratory
Livermore, California

April 1, 1983

We present scattered light measurements from the first 1 ns Novette experiments, with emphasis on Raman scattering and two-plasmon decay. The Novette laser facility, with up to 5 kJ of green light energy per beam, is capable of creating plasmas similar in size to those previously attained on Shiva at 1.06 μm. We will compare these new measurements with previous ones, both from Shiva (large plasmas irradiated at 1.06 μm), and from Argus (small plasmas irradiated at 0.53 μm).

1212I

ABSTRACT

Short-Pulse Experiments at Novette Laser Facility

D. L. Matthews, R. L. Kauffman, C. Wang, P. H. Lee,
R. P. Drake, E. M. Campbell, P. Hagelstein,
and K. Estabrook

Lawrence Livermore National Laboratory
Livermore, California

April 1, 1983

In this paper we present the results from a series of short-pulse (100 psec) 0.525 μm experiments conducted at the Novette facility. Targets consisted of both low- (Formvar) and moderate- (Ni) Z foils irradiated at intensities from 5 x 10^{12} W/cm^2 to 4 x 10^{14} W/cm^2. Both spherical and cylindrical focusing were used. Measurements include absorption, suprathermal x-ray emission, x-ray imaging, and detailed measurements of the emission spectroscopy from the foils.

1214I

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June 5-10, 1983

Magnetic Bubble Formation Produced by an Expanding Laser Plasma*

S.T. Kacenjar,(a), J.A. Stamper, B.H. Ripin, J. Grun,(b) and E.A. McLean

Naval Research Laboratory, Washington, DC 20375

In laser-plasma experiments, where the target is located in an ambient gas and magnetic field, the expanding target plasma can transfer momentum to the ambient through collisional and collective plasma processes. Examples of the latter include the Magnetized Ion-Ion and the Modified Two-Stream instabilities. Threshold conditions are functions of the target plasma thermal speed, the Alfven velocity and the electron beta. The magnetic field strength is fundamental to the excitation of these instabilities. If sufficient compression of the magnetic field is produced by the expanding target plasma, then collective plasma coupling may exist.

We report on an initial study at NRL to measure the degree of magnetic field compression using magnetic induction probes. Planar carbon targets were irradiated using the Pharos II laser (1.05 μm) and placed in a magnetic field of 800 gauss. A background H_2 gas was introduced whose pressure was varied.

Compressed magnetic field regions have been observed with widths on the order of 1 cm FWHM. The magnetic bubbles have been measured to travel at velocities equal to/or slightly greater than the plasma expansion velocities measured with CVI time-of-flight spectroscopy and with charge collectors. Also presented will be preliminary data on the scaling of the magnetic field compression with laser energy and with distance from target.

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*Work supported by the Defense Nuclear Agency.
(a) NRC-NRL Postdoctoral Research Associate.
(b) Mission Research Corporation, Alexandria, VA.

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L4

U-1345ab

PLASMA DENSITY DISTRIBUTIONS FROM LASER-IRRADIATED AU DISK TARGETS

C. L. Shepard, R. R. Johnson, and Gar. E. Busch
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(313)769-8500

The spatial distribution of plasma resulting from laser irradiation of Au disk targets has been determined by Abel inversion of holographic interferograms. The laser wavelength was 0.53 μm and the light intensity at the target surface ranged from 10^{14} to 10^{15} W/cm^2 with a pulse length from 0.6 to 1.0 ns. The UV holographic probe pulse was 20 ps in duration. The time evolution of the plasma has been studied by varying the time between the leading edge of the laser pulse and the holographic probe pulse for different target shots. This time interval ranged from 50 to 900 ps. For a plasma density of 2.5×10^{20} electrons/cm^3, the expansion velocity was determined to be $\sim 3 \times 10^7$ cm/sec.

L5

MASS ABLATION RATES AND ABLATION PRESSURES IN PLANAR TARGETS

A. Ng, D. Pasini, J. Kwan and P. Celliers

Dept. of Physics, University of British Columbia
Vancouver, B.C., Canada, V6T 1A6

Laser-driven ablation in planar aluminum targets have been studied using 0.53 and 0.355 μm laser light. The 2 nanoseconds (FWHM) laser pulse was focussed on target with f/10 optics and the focal spot diameter was 80 μm. Absorbed laser intensity Φ_{Abs} was $< 4 \times 10^{13}$ ω/cm^2. The ablative flow of ions from target front side was measured by arrays of Faraday cups and mini-calorimeters. The mass ablation rate $\dot{m}$ was observed to vary as $\Phi_{Abs}^{0.58}$ and $\Phi_{Abs}^{0.64}$ for the 0.53 μm and 0.355 μm radiation respectively. Within the range of intensities used in this experiment, $\dot{m}$ scaled approximately as $\lambda_L^{-1.38}$. The ablation pressure P was found to scale as $\Phi_{Abs}^{0.75}$ and $\Phi_{Abs}^{0.84}$ for 0.53 μm and 0.355 μm respectively. Also, P scaled approximately as $\lambda_L^{-0.3}$ which is consistent with experimental results from other laboratories.

Nonlinear Development of the Rayleigh-Taylor Instability of a Thin Sheet in Three Dimensions

Denis G. Colombant, W. M. Manheimer and E. Ott*
Plasma Physics Division
Naval Research Laboratory

Due to computer limitations, all nonlinear studies of the Rayleigh-Taylor instability of an ablatively accelerated plasma have been done in two dimensions. A crucial issue then is whether three dimensional effects add any important new physics. To investigate this question, we extend a model for the Rayleigh-Taylor development of a thin sheet by one of us.[1] This model gives analytic results for the nonlinear development in two dimension which agree well with full scale simulations.[2] The three dimensional extension can be solved numerically. In either two or three dimensions, the model of Ref. 1 is not valid when the flow becomes singular and the spike forms. However, it is valid in the bubble (non singular) region whether or not a spike is present elsewhere.

We calculate the rate of burn through of the bubble in two and three dimensions. The conclusion is that the burn through rate is not particularly different in two and three dimensions. Another diagnostic under development is a comparison of the bubble mass as a function time in two and three dimensions. Results of this will be presented if available.

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* Current address: University of Maryland.

1. E. Ott, Phys. Rev. Lett. 21, 1429 (1972).

2. C. P. Verdon, et al, Phys. Fluids 25, 1653 (1982).

A COMPARISON OF SHORT AND LONG PULSE 1μm LASER PRODUCED PLASMA BEHAVIOUR

M.D.J. Burgess, R. Dragila, B. Luther-Davies,
K.A. Nugent, A. Perry, G.J. Tallents.

Department of Engineering Physics,
Research School of Physical Sciences,
The Australian National University,
Canberra, ACT 2600 Australia

The single beam high-power Nd:glass laser at the ANU can provide a flexible combination of synchronised long (<7ns) and short pulses (>10ps) for plasma production and diagnostic purposes.

This poster will present experimental evidence from measurements of critical density profile modification and temporally, spatially and spectrally resolved second harmonic emission that for short pulse irradiation, the dominant interaction process over an intensity range $10^{14} - 10^{17}$ Wcm^{-2} would appear to be resonance absorption, even for nominally normally incidence laser light due to ion-acoustic turbulence induced rippling of the critical density surface.

For long laser pulses the interaction processes become more complex and recent measurements of profile modification; X-ray, harmonic and sub-harmonic emission from long and short pulse irradiation experiments will be presented, illustrating the interpretational difficulties.

SESSION M

Short Wavelength, Long Scalelength, Targets (Oral)

Friday, June 10
8:30 a.m.—10:45 a.m.

R. R. Johnson, Chairman
KMS Fusion, Inc.

IMPROVEMENT OF IMPLOSION IN NEW TYPE TARGETS

C. YAMANAKA

Institute of Laser Engineering
Osaka University
Suita, Osaka, 565 Japan

M2

ABSTRACT

Update on the First Novette Experiments

R. P. Drake, R. E. Turner, D. W. Phillion, E. M. Campbell,
F. Ze, W. C. Mead, B. L. Lasinski, K. Estabrook

Lawrence Livermore National Laboratory
Livermore, California

April 1, 1983

We will present results of the first one ns experiment on the Novette facility at the Lawrence Livermore National Laboratory. This talk will first discuss the status of the Novette facility, and our measurements of the beam uniformity, and focusability obtained with several kilojoules of 0.53 micron light. Next, we will show results from disk target irradiations at intensities from 10^{14} W/cm^2 to 10^{15} W/cm^2. These results include measurements of laser light absorption and scattering using arrays of photodiodes that detect scattered green light, stimulated Raman scattering, and light scattered at the 3/2 harmonic. Finally, we will show early results obtained with additional diagnostics or other targets if they are available.

~~First~~ Last Analysis of ~~Early~~ Late ~~Novette~~ Argus Experiments*

W. C. Mead, R. P. Drake, E. M. Campbell, R. E. Turner,
D. W. Phillion, W. L. Kruer, B. F. Lasinski,
K. G. Tirsell, and C. Wang

Lawrence Livermore National Laboratory
University of California, Livermore, CA 94550

We analyze the results of early disk target irradiations using the Novette laser at 0.53 μm wavelength, 2-4 kJ energy, 1 ns pulse duration, and 10^{14} - 10^{15} W/cm^2 intensities. The results are compared with Shiva 1.06 μm irradiations at similar spot-sizes, Argus 0.53 μm irradiations at smaller spot-sizes, and with LASNEX calculations. We discuss the preliminary results on laser-light absorption and scattering, thermal and suprathermal electron heating, and characteristics of optical and x-ray emissions observed for these plasmas.

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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.

M4

Comparison of Laser-plasma Interaction at $\lambda = 1.3$ µm and 0.44 µm

A.G.M. Maaswinkel, G.P. Banfi, K. Eidmann, E. Fill,
R. Sigel, G.D. Tsakiris, S. Witkowski.

Max-Planck-Institut für Quantenoptik, D-8046 Garching, FRG

Abstract:

A comparative study of laser-plasma interaction at 1.3 µm and 0.44 µm has been performed at the Garching iodine laser facility. Tripling efficiency of the 100 J/300 ps/1.3 µm pulses was 40-50%. Main emphasis in the present investigation was on the acceleration of thin foils and its dependence on laser wavelength, intensity and target material (plastic and gold). 4π reflectivity as well as the angular distribution of reflected light and the variation of its spectrum with angle were measured. Plasma evolution and the hydrodynamic response of the foils were visualized with a novel photographic diagnostic (λ = 580 nm) with which a sequence of 6 frames (either shadowgrams or interferograms) were obtained in a single iodine laser shot. Exposure time was less than 10 ps; time delay between frames as short as 370 ps. Hydrodynamic data like pressure and mass ablation rate were deduced from these measurements and compared with computational results. In an additional experiment the influence of the inhomogeneity of the laser focal spot distribution on plasma uniformity and acceleration was investigated by modulating the laser beam profile at the two wavelengths.

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Hydrodynamic Modeling of Longer-Scalelength Interaction Experiments*

J.H. Gardner, M.H. Emery, J. Grun[a)], M.J. Herbst, R.L. Lehmberg,

E.A. McLean, J. A. Stamper, F.C. Young

Present-day laser systems do not have the energy to directly generate the high plasma temperature, long plasma scalelength, and high laser irradiance that will be characteristic of high-gain target configurations. It is necessary, however, to investigate the long scalelength regime since many deleterious plasma instabilities are scalelength-dependent. Two beams of the Pharos laser system at NRL are being used in a novel approach investigating the interaction of a high-intensity laser beam with longer-scalelength plasmas. One beam is focused on target at a large focal diameter with a 4-nsec laser pulse at low intensity to generate a relatively cool long-scalelength plasma. The second beam with a short (≈ 0.3 nsec) pulse is tightly focused at the center of this focal spot to produce a high intensity beam which heats the long-scalelength plasma and provides a testbed to investigate laser interactions in longer-scalelength plasmas.

In this paper we present the results of a series of hydrodynamic calculations which aid in the analysis and understanding of this experiment. These results are obtained with the FAST2D laser-shell simulator which solves the coupled hydrodynamic thermal-conduction equations for an ionized gas in R-Z coordinates. Laser absorption is by inverse Bremsstrahlung with a dump at the critical surface to represent resonant absorption.

Simulations indicate that the plasma scalelength is best controlled by using focal-spot-size variations to change the scalelength through two-dimensional hydrodynamic expansion. In the experiment, scalelengths are varied by aperturing the incident laser beam at constant peak intensity to provide background plasmas of similar temperature with varying scalelengths.

A crucial factor in the interaction of the high intensity (short) pulse with the background plasma is how much the plasma profiles are perturbed by the short pulse. For sufficiently large energies in the high intensity pulse a plasma channel is formed which may have severe impact on the interaction of the short-pulse beam with the background plasma. Detailed profiles of several cases of varying scalelength and varying energy of the short pulse will be presented. Implications for long-scalelength plasma experiments will be discussed.

* Work supported by USDOE and ONR

a) Mission Research Corporation, Alexandria, VA

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Alberta, Canada (June 5-10, 1983)

Longer-Scalelength Plasma Perturbations by an Intense Laser Beam*

J.A. Stamper, F.C. Young, M.J. Herbst, S.P. Obenschain, J.H. Gardner,
R.H. Lehmberg, E.A. McLean, J. Grun,[a] K.J. Kearney,[a] and B.H. Ripin

Plasmas with density scalelengths longer than usual (up to 400 μm at .1 critical) are used to more closely approximate the blowoff conditions expected for a high-gain ICF pellet. These plasmas are produced by focusing one beam (≃ 150 J, 4 nsec FWHM) of the Pharos II Nd laser ($\lambda = 1.054$ μm) to larger focal spots (< 1 mm); the spot size of this beam may be varied to change the background plasma scalelength in a controlled manner. The other beam is tightly focused to produce intensities up to 10^{15} W/cm^2 which are of interest for laser coupling to the high-gain pellet. The peak intensities of the two pulses occur at nearly the same time. The pulsewidth of the second beam is shortened to ≃ 0.3 ns to minimize hydrodynamic perturbations to the longer-scalelength plasma. However, perturbations do occur. Evidence for these perturbations is found in the spatially resolved but time-integrated harmonic emission and in the temporally resolved but spatially integrated thermal x-ray emission.

Time-resolved x-ray observations indicate that a significant change from the background plasma temperature occurs during the short-pulse irradiation. Two filtered scintillator-photodiodes with subnanosecond time resolution look at the spatially-integrated emission in the 1-5 keV spectral region. "Temperatures" inferred from the ratio of the two detector signals indicate an increase in temperature during the high intensity irradiation; comparisons are made with spatially-integrated bremsstrahlung spectra produced by a 2-D hydrodynamics model.

Imaging of harmonic emission provides evidence of background plasma perturbation by the tightly-focused beam. Light at the second harmonic and either the third or three-halves harmonic is imaged by an f/2.8 lens viewing parallel to the target surface. On some shots, a Wollaston prism is used to image the second harmonic emission with polarization resolution. For lower incident energies ($\lesssim$ 10 J) in the tightly-focused beam, a single, well-defined region of second harmonic emission is observed near the target. As the incident energy in that beam is raised, two regions of emission are frequently observed. The region near the target tends to extend further in toward the target, and can be filamentary in appearance. A second region arises further out in the underdense plasma, and is often filamentary in appearance. Both of these regions appear at a distance from the target that is correlated with the background plasma scalelength, suggesting that they occur at comparable densities under the different conditions. The polarization and radial structure of the second emission region are consistent with lower density channel formation by the tightly focused beam. Comparisons with 2-D hydrodynamic code results are made.

*Work supported by the U.S. Department of Energy and Office of Naval Research.
[a] Mission Research Corporation, Alexandria, VA

M7

13th Annual Anomalous Absorption Conference
Alberta, Canada (June 5-10, 1983)

X-Ray Production in Long Scalelength Interaction Experiments*

ouk

F.C. Young, M.J. Herbst, J.H. Gardner, K.J. Kearney,[a] J.A. Stamper,
S.P. Obenschain, J. Grun,[a] R.H. Lehmberg, E.A. McLean, and B.H. Ripin

The interaction of a high intensity laser beam ($I > 10^{14}$ W/cm^2) with long scalelength plasmas ($|n_e/\nabla n_e| \lesssim 400$ μm at 0.1 critical density) is being studied experimentally by using two beams from the Pharos II Nd laser ($\lambda = 1.054$ μm). A low-intensity defocused beam of 4-nsec duration produces background plasmas of variable scalelength from a solid plastic target. A 0.3-nsec focused beam timed to arrive on target near the peak of the long pulse interacts with this long scalelength plasma. Temporally and spatially integrated bremsstrahlung intensities from 1 to 50 keV are measured. X-ray spectra deduced from the measurements are used to evaluate target heating (based on 1-5 keV x rays) and to determine the relative importance of energetic electron production by plasma instabilities in the underdense region (based on 10-50 keV x rays).

The thermal x-ray emission is dominated by the higher energy 4-nsec laser pulse and corresponds to electron temperatures of about 300 eV. The intensity of this emission scales with the laser energy, as expected. Temperatures determined from these measurements are compared with those extracted using time-resolving x-ray diagnostics as noted in the previous abstract. Also, spectral comparisons are being made with spatially and temporally integrated bremsstrahlung spectra determined from a 2-D hydrocode analysis of this experiment.

The dependence of the intensity of energetic x-ray emission and the associated hot electron temperature, T_h, on the background plasma scalelength and the energy of the short pulse will be reported. Values of T_h range from 5 to 10 keV and changes in the energetic x-ray intensity of more than an order of magnitude are observed in the experiment. For low energy in the short pulse, the energetic x-ray emission increases with background plasma scalelength, but this behavior is not maintained as the energy is increased. These observations are probably due to perturbation of the background plasma by the high-intensity short pulse.

* Work supported by U.S. Department of Energy and Office of Naval Research.

a) Mission Research Corporation, Alexandria, VA

SESSION N

Final Discussion and Next Year's Meeting

Friday, June 10
11:00 a.m. — 12:30 p.m.

A. A. Offenberger, Chairman
University of Alberta

13th ANNUAL
ANOMALOUS ABSORPTION CONFERENCE

List of Pre-registered Attendees

1. ALBRITTON, James R., L-477, Lawrence Livermore Laboratory P.O. Box 5508, Livermore, CA 94550, U.S.A.

2. AL-SHIRAIDA, Y., Department of Electrical Engineering, The University of Alberta, Edmonton, Alberta, Canada.

3. ATTWOOD, David, Lawrence Livermore Laboratory, P.O. Box 808, University of California, Livermore, CA 84550, U.S.A.

4. BALDIS, Hector A., Division of Physics, National Research Council, Ottawa, Ontario, K1A 0R6, Canada.

5. BARNARD, A.J., Physics Department, University of British Columbia, Vancouver, B.C., V6T 1W5, Canada.

6. BARNES, Chris, MS-531, Los Alamos Scientific Laboratory, P.O. Box 1663, Los Alamos, NM 87545, U.S.A.

7. BEGAY, Fred, MS-554, Group L-4, Los Alamos Scientific Laboratory, P.O. Box 5508, Los Alamos, NM 87545 U.S.A.

8. BELL, A.R., Science Research Council, Rutherford Laboratory, Chilton, Didcot, Oxon, England.

9. BENATTAR, R., Laboratoire de PMI, Ecole Polytechnique, 91.128 Palaiseau-Cedex, France.

10. BERGER, Richard L., KMS Fusion, Inc., P.O. Box 1567, Ann Arbor, MI 48106, U.S.A.

11. BERGER, R., AERB FL-10, University of Washington, Seattle, WA 98195.

12. BERNARD, John E., Department of Physics, University of British Columbia, Vancouver, B.C. V6T 1W5

13. BESNARD, D., Los Alamos National Laboratory, P.O. Box 1663, MS-B258, Los Alamos, New Mexico, 87545 U.S.A.

14. BEZZERIDES, B., Los Alamos Scientific Laboratory, P.O. Box 5508, Los Alamos, NM 87545, U.S.A.

15. BODNER, S., Code 4790, Naval Research Lab., Washington, D.C. 20375, U.S.A.

16. BOYD, T.J.M., School of Mathematics, University of Wales, U.C.N.W., Bangor

    N. Wales, LL57 2UW U.K.

36. FUJITA, Hisanori, Institute of Laser Engineering, Osaka University, Yamada-oka 2-6, Suita, Osaka, 565 Japan.

37. GARDNER, John H., Naval Research Laboratory, Code 4040, Washington D.C., 20375.

38. GILES, R., Dept. of Electrical Engineering, University of Alberta, Edmonton, Alberta, T6G 2G7 Canada.

39. GITOMER, Steven J., Los Alamos Scientific Laboratory, P.O. Box 5508, Los Alamos, NM 87545, U.S.A.

40. GODWIN, R.P., Los Alamos Scientific Laboratory, P.O. Box 1663, University of California, Los Alamos, NM 87544, U.S.A.

41. GOLDMAN, L.M., Laboratory for Laser Energetics, University of Rochester, 250 E. River Road, Rochester, NY 14623, U.S.A.

42. GOLDMAN, Robert, Los Alamos National Laboratory, MS E531, Los Alamos, NM 87545.

43. GRUN, J., Mission Research Corp., Alexandra, VA 20375, U.S.A.

44. HAMMERLING, Peter, La Jolla Institute, P.O. Box 1434, La Jolla, CA 92038, U.S.A.

45. HERBST, Mark J., Naval Research Laboratory, Washington, D.C. 20375, U.S.A.

46. JAMES, R., Department of Electrical Engineering, University of Alberta, Edmonton, Alberta, T6G 2G7 Canada.

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