14th ANNUAL
ANOMALOUS ABSORPTION
CONFERENCE

MAY 6-11, 1984

THE BOAR'S HEAD INN, CHARLOTTESVILLE, VA

14th Annual

ANOMALOUS ABSORPTION CONFERENCE

May 6-11, 1984

The Boar's Head Inn
Charlottesville, VA

PROGRAM

Sunday, May 6

5:00-8:00 pm — Registration

8:00 pm — Welcoming Reception (champagne and hors d'oeuvres)

Monday, May 7

Session A
SBS, Self-Focusing, Long-Scalelength and Finite-Bandwidth (oral)

8:20 am — 12:30 pm

Chairman: H. Baldis (NRC)

8:20-8:30		Introductory Remarks
8:30-8:45	A1	"Filamentation, Self-Focussing and Hot Electrons," J.M. Kindel and D.W. Forslund, LANL.
8:45-9:00	A2	"Interaction Experiments in Quasi Homogeneous Plasmas," C. Labaune, E. Fabre, F. Briand A. Michard, Ecole Polytechnique, France, and J. Briand, CPAT. Toulouse.
9:00-9:15	A3	"Thermal Self-Focusing at Oblique Incidence," R.S. Craxton and R.L. McCrory, Univ. of Rochester.
9:15-9:30	A4	"Large Scalelength Experiments at 1.06 μm and 0.53 μm," E.M. Campbell, R.P. Drake, R.E. Turner, D.W. Phillion, W.L. Kruer, B.F. Lasinski, C.L. Wang, K.G. Estabrook, and C.W. Hatcher, LLNL.
9:30-9:45	A5	"Feedback Effects on Stimulated Backscattering from Laser-Produced Plasmas," G.R. Mitchel and T.W. Johnston, INRS-Energie, Canada.
9:45-10:00	A6	"Interaction Physics from Underdense Plasmas," V. Aboites, T.P. Hughes, E. McGoldrick and S.M.L. Sim, University of Essex, England, S. Karttunen, Technical Research Centre of Finland, R.G. Evans, Rutherford Appleton Laboratory, England.
10:00-10:15	A7	"Energetic X-Ray and $3/2\text{-}\omega_0$ Emission from Long-Scalelength Laser-Plasma Interactions," F.C. Young, M.J. Herbst, K.J. Kearney, C.K. Manka, S.P. Obenschain and J.A. Stamper, NRL.
10:15-10:30	A8	"Double Stimulated Scattering and the Development of the Theory of Parametric Instabilities of Plasmas," V.T. Tikhonchuk, Lebedev Physical Institute, USSR.
10:30-11:00		Coffee Break
11:00-11:15	A9	"Long-Scalelength Plasma Experiments Using Thin Foil Targets," R.P. Drake, R.E. Turner, K.G. Estabrook, B.F. Lasinski, D.W. Phillion, R.L. Kauffman, S.A. Letts, E.A. Williams, E.M. Campbell, C.W. Hatcher, and W.L. Kruer, LLNL.

11:15-11:30 A10 "Optical Spectroscopy From Thin Foil Targets, R.E. Turner, R.P. Drake, D.W. Phillion, K.G. Estabrook, B.F. Lasinski, R.E. Ellis, W.L. Kruer, and E.M. Campbell, LLNL.

11:30-11:45 A11 "Hydrodynamic Expansion of Thin Foil Targets," D.W. Phillion, R.L. Kauffman, K.G. Estabrook, R.E. Turner, R.P. Drake, E.M. Campbell, and B.F. Lasinski, LLNL.

11:45-12:00 A12 "X-ray Spectroscopy From Doped Thin Foil Targets," R.L. Kauffman, R.W. Lee, B.L. Whitten, R.P. Drake, R.E. Turner, K.G. Estabrook, B.F. Lasinski, D.W. Phillion, S.A. Letts, and E.M. Campbell, LLNL.

12:00-12:15 A13 "Reflectivity From Stimulated Brillouin Backscattering for a Broadband Incident Light," A. Bortuzzo-Lesne, G. Laval, and D. Pesme, Ecole Polytechnique, France.

12:15-12:30 A14 "Experimental Tests of Induced Spatial Incoherence," S.P. Obenschain, F.C. Young, R.R. Whitlock, J.A. Stamper, B.H. Ripin, M. Pronko, E.A. McLean, C.K. Manka, R.H. Lehmberg, S. Kacenjar, M.J. Herbst, J. Grun and S.E. Bodner, NRL.

Session B
Raman and $2\omega_p$ I (oral)

6:30 — 7:45 pm

Chairman: B. Lasinski (LLNL)

6:30-6:45 B1 "A New Model of Raman Spectra in Laser Produced Plasma," A. Simon and R.W. Short, University of Rochester.

6:45-7:00 B2 "Electron Plasma Wave Production by Convective SRS," H.A. Baldis, C.J. Walsh and D.M. Villeneuve, National Research Council, Canada.

7:00-7:15 B3 "k-resolved Measurement of Plasma Waves from SRS," D.M. Villeneuve, H.A. Baldis and C.J. Walsh, National Research Council, Canada.

7:15-7:30 B4 "Influence of Raman Scattering on Half-Integer Harmonics in a 1.06 μm Laser Produced Plasma," V. Adrian, J. Briand, M. El Tamer, A. Gomes, Y. Quemener, J.C. Kieffer, and J.P. Dinguirard, Universite Paul Sabatier, France.

7:30-7:45 B5 "Raman Scattering in a Nearly Resonant Density Ripple," F.F. Chen, and H.C. Barr, UCLA.

Session C
Raman and $2\omega_p$ II (poster)

8:00 — 10:00 pm

C1 "Detection of High Frequency Instability Through the Satellites of a He II Line," B. Amini and F.F. Chen, UCLA.

C2 "Energy Balance and Temperature in a CO_2 Laser Produced Plasma," R. Popil, J. Meyer and B. Ahlborn, University of British Columbia, Canada.

C3 "The $2\omega_{pe}$ Instability for Low Temperature, Inhomogeneous Plasmas," C. Grebogi, University of Maryland and W. Manheimer, NRL.

C4 "Laser Plasma Coupling in Long Scale Length, High Z Plasmas," W.L. Kruer, K. Estabrook and B.F. Lasinski, LLNL.

C5 "Analysis of Novette Disc Irradiations," B.F. Lasinski, R.P. Drake, R.E. Turner, K.G. Estabrook, C.L. Wang, E.A. Williams, D.W. Phillion, W.L. Kruer, and E.M. Campbell, LLNL.

C6 "Half Harmonic Light Spectra Produced by Two-Plasmon Decay," L.V. Powers and R.L. Berger, KMS Fusion.

C7 "Raman Sidescattering in Laser-Produced Plasma," C.R. Menyuk, N.M. El-Siragy, University of Maryland and W.M. Manheimer, NRL.

C8 "Plasma Simulation Study of Stimulated Raman Scattering," G. Bonnaud and C. Reisse, Limeil, France.

C9 "Spotsize Effects on Raman Sidescatter," B. Afeyan, University of Rochester and E.A. Williams, LLNL.

Tuesday, May 8

Session D
Hot ELectrons and Ions (oral)

8:30 am — 12:15 pm

Chairman: D. Forslund (LANL)

8:30-8:45	D1	"Trapped Electron Instability in Laser Fusion Plasmas," M.A. True, KMS Fusion.
8:45-9:00	D2	"Anomalous Absorption and Hot Electron Production," W. Rozmus, W. Tighe and A.A. Offenberger, University of Alberta, Canada.
9:00-9:15	D3	"Two-dimensional Hybrid Simulation of Suprathermal Electron Transport," R.J. Mason, LANL.
9:15-9:30	D4	"Fast Electrons from Localized Strong Coherent Travelling Waves," T.W. Johnston, INRS-Energie, Canada.
9:30-9:45	D5	"Energy Balance Experiments on ANTARES," J.F. Kephart, D. Bach, G.E. Eden, S.J. Gitomer, P.D. Goldstone, R. Kristal, C. Mansfield and M.A. Yates, LANL.
9:45-10:00	D6	"T_{hot} Studies with Defocused Laser Beams and Large Spots," G.A. Kyrala, LANL.
10:00-10:15	D7	"Imaging of Hot Electrons Produced by Parametric Instabilities in a 1.06 μm Laser Created Plasma," J.C. Kieffer, J. Briand, V. Adrian, A. Gomes, Y. Quemener, J.P. Dinguirard, and M. El Tamer, Universite Paul Sabatier, France.
10:15-10:45		Coffee Break
10:45-11:00	D8	"Search for Very High Energy Electrons in an Underdense CO_2 Laser Plasma," D.R. Bach, M.A. Yates, D.E. Casperson, D.W. Forslund, J.S. Ladish, F.B. Harrison, and K.R. Winn, LANL.

11:00-11:15 D9 "Time Resolved Measurements of Two Plasmon Decay Waves Correlated to Fast Electron Generation in CO_2-Laser-Plasma Interactions," J. Meyer, H. Houtman and G. McIntosh, University of British Columbia, Canada.

11:15-11:30 D10 "Fast Ion Imaging with a Pinhole Camera on CO_2-Laser Plasmas," R. Decoste, D. Pascale, J.C. Kieffer, H. Pepin, and P. Lavigne, Institut de Recherche d'Hydro-Quebec, Canada.

11:30-11:45 D11 "Fast Ion Emission in Laser Matter Interactions—Theory and Experiment," S.J. Gitomer and R.D. Jones, LANL.

11:45-12:00 D12 "Physics of the Laser-Plasma Interaction at a Local Maximum of the Plasma Density," T. Speziale, KMS Fusion.

12:00-12:15 D13 "The Role of Caviton Formation in Saturation of Parametric Instabilities," B. Bezzerides, C. Aldrich, K. Lee, D.F. DuBois and H. Rose, LANL.

Session E
Raman and $2\omega_p$ II (oral)

6:30 — 7:45 pm

Chairman: A. Simon (University of Rochester)

6:30-6:45 E1 "Experiments with Disk Targets Irradiated with 0.53 and 1.05 μm Laser Light," C.L. Shepard, Gar. E. Busch, R.R. Johnson, R. J. Schroeder and J.A. Tarvin, KMS Fusion.

6:45-7:00 E2 "How Useful Are Odd-Integer Half-Harmonics?," W. Seka, L.M. Goldman, K. Tanaka, B. Afeyan, A. Simon and R. Short, University of Rochester.

7:00-7:15 E3 "Evidence for $2\omega_p$ Decay of 1053 nm Light in a Gold Plasma at 3×10^{13} W/cm^2," J.A. Tarvin, R.L. Berger, L.V. Powers, R.J. Schroeder and C.L. Shepard, KMS Fusion.

7:15-7:30 E4 "Observation of Scattered Light Between $\omega/2$ and $3/2\omega$ in Short Wavelength Laser Produced Plasmas," L.M. Goldman, W. Seka, K. Tanaka, A. Simon and R. Short, University of Rochester.

7:30-7:45 E5 "Some Topics in Raman Scattering," E.A. Williams, LLNL.

Session F
SBS, Self-Focusing and Quarter-Critical Processes (poster)

8:00 — 10:00 pm

F1 "Brillouin Scattering in Underdense UV Laser-Produced Plasma," K. Tanaka, B. Boswell, R.S. Craxton, L.M. Goldman, M.C. Richardson, W. Seka, R.W. Short and J.M. Soures, University of Rochester.

F2 "Nonstationary Thermal and Pondermotive Filamentation of 'Incoherent' Laser Light," A.J. Schmitt, NRL.

F3 "Reduction of Reflectivity in Stimulated Brillouin Scattering Due to Incoherency Effects," M. Casanova, Limeil, France, R. Pellat and D. Pesme, Ecole Polytechnique, France.

F4 "Stimulated Brillouin Scattering in Plasmas with Z > 1 and Multiple Z Plasmas," R.W. Huff and J.M. Dawson, UCLA.

F5 "Nonlinear Saturation of the Parametric Instability for Three Coupled Oscillators," A. Simon, C.J. McKinstrie and E.A. Williams, University of Rochester.

F6 "3/2 ω Spectra from Gold Disks Simultaneously Irradiated with 526 and 1053 nm Laser Light," R.J. Schroeder, R.L. Berger, L.V. Powers, J.A. Tarvin and C. Shepard, KMS Fusion.

F7 "First Tests of the LASNEX 3D Raytrace Laser," A. Friedman, LLNL.

F8 "Numerical Modelling of Filamentation in Long Scalelength Laser Plasmas," R.H. Lehmberg, J.A. Stamper, J.H. Gardner and M.J. Herbst, NRL.

Wednesday, May 9

Session G
Thermal Transport (oral)

8:30 am — 12:00 pm

Chairman: J. Meyer (University of British Columbia)

8:30-8:45	G1	"Nonlocal Heat Transport by Non-Maxwellian Electrons," K. Swartz and R.W. Short, University of Rochester.
8:45-9:00	G2	"Heat Conduction Through a Potential Barrier in Laser-Plasma Interaction," M.S. Chu, R.W. Harvey, F.L. Hinton and C.S. Liu, GA Technologies.
9:00-9:15	G3	"Spectroscopic Evaluation of the Heat Front Profile in Laser Plasma Transport Experiments," A. Hauer, W. Mead, O. Willi, LANL, J.D. Kilkenny, Imperial College and D. Duston, NRL.
9:15-9:30	G4	"Electron Transport and Plasma Profiles in 1.06 μm Multilayer Spherical Transport Experiment," W.C. Mead, A. Hauer, O. Willi, M. Mahaffy, LANL, D. Duston, NRL and J.D. Kilkenny, Imperial College.
9:30-9:45	G5	"Electron-Ion Collisions in Laser-Plasmas," J.R. Albritton, LLNL.
9:45-10:00	G6	"Time-Resolved Measurements of the Ionization Front in Transport Studies," R.S. Marjoribanks, M.C. Richardson, B. Yaakobi, O. Barnouin, J. Delettrez, R. Epstein and W. Beich, University of Rochester.
10:00-10:15	G7	"Thermal Transport Measurements in Six-Beam, UV Irradiation of Spherical Targets," O. Barnouin, J. Delettrez, L.M. Goldman, R. Marjoribanks, M.C. Richardson, J.M. Soures and B. Yaakobi, University of Rochester.
10:15-10:45		Coffee Break
10:45-11:00	G8	"Non-LTE Considerations in Spectral Diagnostics of Thermal Transport and Implosion Experiments," R. Epstein, S. Skupsky, J. Delettrez and B. Yaakobi, University of Rochester.
11:00-11:15	G9	"Solution of the Vlasov-Fokker-Planck Equation for a Laser-Produced Spherically-Symmetric Steadily-Ablating Plasma," A.R. Bell, Rutherford Appleton Lab, England.

11:15-11:30 G10 "Transport Effects of Interacting Hot and Cold Electron Populations in Steep Temperature and Density Gradients," P.M. Campbell and J.T. Larsen, KMS Fusion.

11:30-11:45 G11 "Limits on the Flux-Limiter and Preheat from Simulations of Experiments on the Omega System at 1054 nm and 351 nm," J. Delettrez, R. Epstein, M.C. Richardson and B.Y. Yaakobi, University of Rochester.

11:45-12:00 G12 "Hydrodynamic Calculations of Inhibited Transport Experiments," J.H. Gardner, M.H. Emery and M.J. Herbst, NRL.

Session H
Plasma Diagnostics (oral)

6:30 — 7:45 pm

Chairman: E. Fabre (Ecole Polytechnique)

6:30-6:45 H1 "X-ray Shadowgraphy and Refractometry of Laser Produced Plasmas," R. Benattar and J. Godart, Laboratoire Plasmas, France.

6:45-7:00 H2 "The Characterization of the Plasma Corona Produced by Short Pulse 1 μm Radiation Using a Line Focus of $\lesssim 10^{15}$ W/cm^{-2}," M.C. Richardson, M.D.J. Burgess, R. Dragila, B. Luther-Davies, K.A. Nugent, A.J. Perry and G.J. Tallents, The Australian National University.

7:00-7:15 H3 "High Spatial Resolution (2D) X-Ray Diagnostics of the Thermal Transport Region in Laser Irradiated Plane Target at 0.53 and 0.26 μm," P. Alaterre, C. Popovics, Ecole Polytechnique, P. Audebert, J.P. Geindre and J.C. Gauthier CNRS, Orsay, France.

7:15-7:30 H4 "Determination of the Z-Dependence of Plasma Expansion Velocities from Disk Targets Using Holographic Interferometry," R.R. Johnson, C.L. Shepard and Gar.E. Busch, KMS Fusion.

7:30-7:45 H5 "Thomson Scattering by the Electron Plasma Wave Excited by Two Laser Beams," B. Amini and F.F. Chen, UCLA.

Session I
Wave-Particle Interactions (poster)

8:00 — 10:00 pm

I1 "Soliton Collapse During Ionospheric Heating," J.P. Sheerin, D.R. Nicholson, G.L. Payne and L.M. Duncan, University of Iowa.

I2 "Electron Heating Due to Parametric Instabilities Near the Critical Surface and Collisional Effects," K. Mizuno, J.S. DeGroot, J.H. Rogers, W. Woo and P.W. Rambo, University of California, Davis, and K. Estabrook, LLNL.

I3 "Transition from Wave Breaking to Thermal Convection in Resonance Absorption," J.P. Nicolle, J. Clerouin, D. Galmiche, Limeil, France.

I4 "Hot Electron Coupling and Transport in 10.6 μm Laser Target Interactions," N.H. Burnett and G.D. Enright, National Research Council, Canada.

I5 "Energetic Electron Distribution in CO_2 Laser-Produced Plasmas," G.D. Enright and N.H. Burnett, National Research Council, Canada.

I6 "One and Two Dimensional Simulations on Beat Wave Acceleration," W.B. Mori, C. Joshi and J.M. Dawson, UCLA, D.W. Forslund and J.M. Kindel, LANL.

I7 "Energy, Space and Time Distribution of Suprathermal X-Rays," C.L Wang, E.M. Campbell, R.P. Drake, K.G. Estabrook, G.R. Leipelt and R.E. Turner, LLNL.

I8 "Tapered Beat-Wave Accelerator," A.B. Langdon and B.I. Cohen, LLNL.

Thursday, May 10

Session J
Transport and B-Fields (oral)

8:30 — 12:15 pm

Chairman: D. Colombant (NRL)

8:30-8:45	J1	"Localized Heat Flow Instabilities in Laser Plasmas," R.W. Short and K. Swartz, University of Rochester.
8:45-9:00	J2	"Irradiation of Glass Microballoons at 0.26 μm," E. Fabre, C. Labaune, A. Michard, F. Briand, Ecole Polytechnique, France, and J. Briand, CPAT Toulouse, France.
9:00-9:15	J3	"The Effect of Thermal Flux Saturation on Lateral Heat Transport— A Multi-Group Analysis," S. Skupsky and J. Delettrez, University of Rochester.
9:15-9:30	J4	"Self-Generated Magnetic Fields and Electron Transport," T. Yabe, A. Nishiguchi, H. Takabe and K. Mima, ILE, Osaka, Japan.
9:30-9:45	J5	"Thermal Flux Inhibition Due to Magnetic Fields," M.H. Emery and J.H. Gardner, NRL.
9:45-10:00	J6	"Quantitative Space and Time Resolved Measurements of the Magnetic Field Produced by High Intensity 1 μm Laser Radiation," M.D.J. Burgess and B. Luther-Davies, The Australian National University.
10:00-10:15	J7	"Delocalized Electron Transport in Homogeneous Magnetic Fields," J. Luciani and P. Mora, Ecole Polytechnique, France.
10:15-10:45		Coffee Break
10:45-11:00	J8	"Magnetically Enhanced Lateral Transport in Cylindrical Geometry," J.M. Wallace, D.W. Forslund and J.U. Brackbill, LANL.
11:00-11:15	J9	"The Dynamo Effect in Laser-Matter Interaction," J. Briand, V. Adrian, M. El Tamer, A. Gomes, Y. Quemener, J.C. Kieffer and J.P. Dinguirard, Universite Paul Sabatier, France.
11:15-11:30	J10	"Scaling of Electron Range Reduction by Magnetic Insulation," K. Lee, LANL.
11:30-11:45	J11	"Effects of Magnetic Fields on IF Driver Requirements," R.D. Jones and W.C. Mead, LANL.

11:45-12:00 J12 "Magnetic Bubble Formation Produced by an Expanding Laser Plasma," S.T. Kacenjar, B.H. Ripin, J.A. Stamper and E.A. McLean, NRL.

12:00-12:15 J13 "Theoretical Framework and Numerical Studies for Modeling Laser Plasma Interaction," P.L. Mascheroni and M.A. Mahaffy, LANL.

Session K
Transport and Hydrodynamics (poster)

7:00 — 10:00 pm

K1 "Analysis of Plasma Expansion and Foil Acceleration Diagnostics from Spectral Shift of Laser Light," E. Fabre, C. Labaune and A. Michard, Ecole Polytechnique, France.

K2 "100 eV Imaging of Laser Produced Plasmas in the Temperature Gradient Region," R. Benattar and J. Godart, Laboratoire Plasmas, France.

K3 "Pressure Scaling of Shock Speed in Laser-Irradiated Solids," D. Parfeniuk, A. Ng and L. DaSilva, University of British Columbia, Canada.

K4 "Penumbral X-ray Imaging Measurements of Magnetic Field Induced Surface Transport Using 1 μm Laser Irradiated Disc Targets," K.A. Nugent, M.D.J. Burgess and B. Luther-Davies, The Australian National University.

K5 "Fokker-Planck-Landau Simulations of Laser-Plasma Interaction," A. Decoster, Limeil, France.

K6 "Electron Heat Flow with Classical and Resonant Absorption and Hydro Motion," J.P. Matte, T.W. Johnston, INRS-Energie, Quebec, J. Delettrez and R.L. McCrory, University of Rochester.

K7 "Laser Burn-Through in Thin Foils," A. Ng, D. Parfeniuk, L. DaSilva and D. Pasini, University of British Columbia, Canada.

K8 "Experimental Data on Electron Transport in Laser Targets," A.H. Bennish, J. Delettrez, G.H. Miley, D.B. Harris, D.R. Welch and A. Entenberg, University of Illinois.

K9 "Laser Beam Cleaning in a Plasma Cell," R. Marchand, C.E. Capjack and C.R. James, University of Alberta, Canada.

K10 "Model for Gain vs. Laser Energy for Direct Drive Targets," M.D. Rosen and J.D. Lindl, LLNL.

K11 "Under-dense, Planar Plasma Production by Low Intensity, Laser-Driven Thin Film Explosions," F.J. Mayer, Gar. E. Busch and J.A. Tarvin, KMS Fusion.

K12 "Experimental Investigation of Satellite Intensities and Line Profiles in Dense Plasma Using Spot Spectroscopy and Knife Edge Imaging," P. Audebert, J.P. Geindre, J.C. Gauthier, Universite Paris, P. Alaterre, C. Popovics, Ecole Polytechnique, M. Cornille and J. Dubau, Observatoire de Paris.

Friday, May 11

Session L
Hydrodynamics and Rayleigh-Taylor (oral)

8:30 — 11:45 am

Chairman: J. Tarvin (KMS)

8:30-8:45	L1	"A KrF Laser Facility for Short Wavelength Laser/Matter Interaction Experiments," A.A. Offenberger, D.C.D. McKen and R. Fedosejevs, University of Alberta, Canada.
8:45-9:00	L2	"LASNEX Modeling of the Osaka High-Z Disc Experiments," E.K. Stover and W.C. Mead, LANL.
9:00-9:15	L3	"Scaling of High-Z Plasma Parameters," S.R. Goldman, W.C. Mead, B. Bezzerides, C.W. Cranfill and R.D. Jones, LANL.
9:15-9:30	L4	"Diagnostic of Plasma Corona Dynamics," Yu. A. Zakharenkov, Lebedev Physical Institute, USSR.
9:30-9:45	L5	"Study of Ablatively Accelerated Targets at $\lambda = 0.26\ \mu m$," R. Fabbro, B. Faral, Ecole Polytechnique, H. Pepin, Universite du Quebec, F. Cottet and J.P. Romain, E.N.S.M.A., France.
9:45-10:00	L6	"Irradiation of Spherical Shell Targets with 6 UV Omega Beams," M.C. Richardson," R. Keck, B. Yaakobi, S. Letzring, J. Delettrez, C. Verdon, J.M. Soures and G. Gregory, University of Rochester.
10:00-10:15	L7	"Studies of the Rayleigh-Taylor Instability in Three Dimensions," D.G. Colombant, W.M. Manheimer and E. Ott, NRL.
10:15-10:45		Coffee Break
10:45-11:00	L8	"Forced Rayleigh-Taylor Instability in Nonuniform Irradiation," H. Takabe, K. Mima and T. Yabe, ILE, Osaka, Japan.
11:00-11:15	L9	"Recent Experimental Results from Rutherford Laboratory," R.G. Evans, Rutherford Laboratory, England.
11:15-11:30	L10	"Growth Rate Scaling in the Ablatively Driven Rayleigh-Taylor Instability," W.M. Manheimer and D.G. Colombant, NRL.
11:30-11:45	L11	"Measurements of Rayleigh-Taylor Caused Mass Redistribution," J. Grun, P.G. Burkhalter, D. Colombant, M.H. Emery, S. Kacenjar, W. Manheimer, E.A. McLean, S.P. Obenschain, C.B. Opal, B.H. Ripin, R.R. Whitlock, NRL and T.J. Goldsack, AWRE, England.

Session M
Plenary Session for next year's meeting

11:45 — 12:15 am

14th Annual Anomalous Absorption Conference

May 6-11, 1984

THE WEEK'S SCHEDULE AT A GLANCE

	MON	TUES	WED	THURS	FRI	
MORNING	A (ORAL) 8:20 AM - 12:30 PM	D (ORAL) 8:30 AM - 12:15 PM	G (ORAL) 8:30 AM - 12:00 PM	J (ORAL) 8:30 AM - 12:15 PM	L (ORAL) 8:30 AM 11:45 AM	M (PLENARY) 11:45 AM - 12:15 PM
AFTERNOON						
EVENING	B (ORAL) 6:30-7:45 PM C (POSTER) 8:00-10:00 PM	E (ORAL) 6:30-7:45 PM F (POSTER) 8:00-10:00 PM	H (ORAL) 6:30-7:45 PM I (POSTER) 8:00-10:00 PM	K (POSTER) 7:00-10:00 PM		

- SOLID AND LIQUID REFRESHMENTS SUNDAY EVENING AT 8:00 PM
- LIQUID REFRESHMENTS MONDAY-THURSDAY EVENINGS AT THE POSTER SESSION

SESSION A

SBS, Self-Focusing, Long-Scalelength, and Finite Bandwidth (oral)

Monday, May 7
8:20 a.m.—12:30 p.m.

Chairman: H. Baldis (NRC)

FILAMENTATION, SELF-FOCUSSING AND HOT ELECTRONS

by

J. M. Kindel and D. W. Forslund
University of California
Los Alamos National Laboratory
Los Alamos, NM 87545

W. B. Mori and C. Joshi
University of California, Los Angeles
Los Angeles, CA 90024

Two-dimensional plasma simulation studies have been carried out for a finite laser beam at high intensities, i.e., 10^{15} to 10^{16} W/cm^2 for CO_2 light incident onto a uniform highly underdense plasma. The purpose of the simulations is to delineate the competition and interplay between various phenomena: forward and backward Raman scattering, stimulated Compton scattering, self-focussing, filamentation, harmonic generation and hot electron production. We compare a particular cold plasma simulation to a recent Los Alamos experiment.[1] We will also compare the single frequency simulation results with some double frequency simulations.[2] Some key results of our study are as follows. Backward Raman increases the number of energetic electrons for forward Raman, consistent with our previous 1-D simulations. In contrast to beat wave simulations, forward Raman has a broad spectral width and is of low amplitude. Significant harmonic emission occurs in the underdense plasma and is enhanced by self-focussing. Harmonic emission is greater at the edge of filaments. Self-focussing and filamentation co-exist and eventually disrupt the underdense electron acceleration.

1. D. Bach, et al, "Search For Very High Energy Electrons in An Underdense CO_2 Laser Plasma," poster paper at this meeting.

2. W. B. Mori, et al, "One- and Two-Dimensional Simulations on Beat Wave Acceleration," poster paper at this meeting.

INTERACTION EXPERIMENTS IN QUASI HOMOGENEOUS PLASMAS

C. LABAUNE, E. FABRE, F. BRIAND, A. MICHARD
(PMI, Palaiseau)
J. BRIAND (CPAT, Toulouse)

The interaction of laser light with homogeneous plasma is studied at laser wavelengths of 0.53 μm and 0.26 μm. The homogeneous plasma is generated by thin plastic foil irradiated with a laser beam focussed onto the target with a large focal spot. Experiment shows that this plasma is transparent for 0.53 μm laser light after 1 ns. The aspect ratio of this plasma (length of inhomogeneity over laser wavelength) is of the order of 200. Another laser pulse is then tightly focussed on this plasma and we have analysed the temporal behaviour of backscattered light. Evidence for Brillouin backscattering is obtained. However, the level is very low : 5-10% of SBS for 0.53 μm at 10^{15} W/cm^2 and ~ 0.1% for 0.26 μm laser wavelength at 10^{15} W/cm^2. The two plasmons instability has been detected by the analysis of 3/2 ω emission. Raman instability is also studied and some time-resolved spectra could be interpreted by its onset at rather moderate fluxes below 10^{15} W/cm^2 at 0.26 μm.

14th Annual Anomalous Absorption Conference
Charlottesville, Virginia
May 6-11, 1984

THERMAL SELF-FOCUSING AT OBLIQUE INCIDENCE

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Abstract

Thermal self-focusing at oblique incidence has been investigated in two-dimensional line-focus geometry using the Eulerian hydrodynamics simulation code SAGE. The laser beam interacts with a long-scale-length preformed plasma with an exponential density profile. Questions to be addressed include: (1) What happens when a self-focusing channel reaches the turning point of the incident rays? and (2) Does the unabsorbed light return in the specular direction or back along the channel? A comparison is also made between thermal self-focusing at normal incidence in cylindrical and line-focus geometries: in cylindrical geometry the self-focusing mechanism is enhanced by the relative ease with which plasma may be expelled from a small cylindrical channel.

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.

Large Scalelength Experiments at 1.06 μm and 0.53μm*

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

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ABSTRACT

The multikilojoule 0.53μm Novette and 1.06μm Shiva lasers allow wavelength scaling experiments to be extended to coronas ($L/\lambda_0 \sim 10^2$-10^3) more characteristic of future high gain targets. In this talk we present and compare the results of laser-plasma interaction experiments conducted at both facilities with incident energies up to 4 kJ (1 nsec FWHM pulse). Experimental results include absorption and stimulated Brillouin scattering and suprathermal electron production and observation of scattered light from the Raman instability and 3/2 ω_0 emission from plasma was near $N_c/4$. The lasers irradiated thick Au and low Z (Be or CH) disks and exploding foils (Au, CH) which are designed to produce very long scalelength plasma.

The results, when compared to low power experiments, continue to demonstrate improved coupling as the laser wavelength decreases. However, processes such as Brillouin sidescatter and efficient stimulated Raman scattering (efficiency > 1-5%), not previously seen in submicron wavelength experiments, have been observed in the larger plasmas produced with Novette.

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

ABSTRACT FOR THE 14th ANOMALOUS ABSORPTION CONFERENCE
MAY 6-11 1984, Charlottesville, VA

FEEDBACK EFFECTS ON STIMULATED BACKSCATTERING FROM LASER-PRODUCED PLASMAS

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Brillouin and Raman backscattering can be enhanced by reflective feedback from underdense plasma structures, such as quarter-critical density profile steepening due to two-plasmon decay. Rapid time modulation of broadband scatter can be explained by modulation of the feedback from a variation of the round trip phase shift due either to motion of the feedback surface, in Brillouin backscattering, or by periodic creation and destruction of the feedback surface itself, as in Raman backscattering. Sufficient feedback can induce temporal growth in spite of possibly supersonic plasma flow and wave damping.

INTERACTION PHYSICS FROM UNDERDENSE PLASMAS

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and

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ABSTRACT

Some recent results from experiments performed at the Central Laser Facility, Rutherford Appleton Laboratory are presented. Thin foils (of aluminium, polystyrene and parylene) were exploded by 1.05 μm or 0.5 μm laser pulses (FWHM = 500 ps to 900 ps) to provide underdense plasma targets. Time resolved spectroscopy was used to observe the half integer harmonic emission in order to study the production of $\omega_o/2$ plasmons by the two plasmon decay instability and the stimulated Raman scattering instability and the subsequent harmonic generation. The results are discussed with the aid of various theoretical models.

14th Annual Anomalous Absorption Conference
Charlottesville, Virginia (May 6-11, 1984)

Energetic X-Ray and 3/2-ω_o Emission from Long-Scalelength Laser-Plasma Interactions*

F.C. Young, M.J. Herbst, K.J. Kearney,[a]
C.K. Manka,[b] S.P. Obenschain and J.A. Stamper

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In earlier work[1] we have observed thresholds for hard x-ray (20-50 keV) emission for irradiances of 10^{14} to 10^{15} W/cm^2 (λ = 1.054 um) on variable scalelength plasmas ($|n/\nabla n|$ from 140 to 320 μm at quarter critical, $n_c/4$). A threshold in irradiance observed for the shortest scalelength suggested the onset of a plasma instability. Variation with scalelength of the hot electron fraction was consistent with an underdense instability, at least at low irradiance. However, hot electron temperatures (T_h) of 6 to 10 keV were much less than expected for either Raman or $2\omega_p$ instabilities; electrons accelerated to the phase velocity of the most unstable plasma waves would have significantly higher T_h.

Our recent efforts have been directed at determining the mechanism for hot electron generation by comparing the intensities of 3/2-ω_o and hard x-ray emissions for variations in irradiance and scalelength. For these measurements, a background plasma with ≈ 500-eV temperature at $n_c/4$, formed with a 4-ns defocused laser beam (~ 6×10^{12} W/cm^2) on planar polyethylene targets, is irradiated with a high intensity 0.3-ns tightly focused beam timed to arrive on target at the peak of the long pulse. The 3/2-ω_o emission is measured at 25° and 50° to the target normal. Also, the intensities of 20 to 115 keV x rays are measured in order to look for larger values of T_h than were detected in the 20 to 50 keV spectral range.

Thresholds are observed in both 3/2-ω_o and hard x-ray emissions at ~ 2×10^{14} W/cm^2 (vacuum irradiance averaged within the diameter containing 50% of the short pulse energy) for short scalelength plasmas. The intensities of these two radiations show similar scaling with laser energy and with increased scalelength. Hot electron production by a quarter-critical instability is strongly implied by these observations. Measurements of the hard x-ray spectra and the spectra of 3/2-ω_o emission in this experiment will be reported.

* Work supported by U. S. Department of Energy and Office of Naval Research.
[a] Mission Research Corporation, Alexandria, VA
[b] Sam Houston State University, Huntsville, TX

Double Stimulated Scattering and the Development of the Theory of Parametric Instabilities of Plasmas

V.T. Tikhonchuk

Lebedev Physical Institute, USSR

Long-Scalelength Plasma Experiments Using Thin Foil Targets*

R. P. Drake, R. E. Turner, K. G. Estabrook, B. F. Lasinski, D. W. Phillion, R. L. Kauffman, S. A. Letts, E. A. Williams, E. M. Campbell, C. W. Hatcher, W. L. Kruer

Lawrence Livermore National Laboratory
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This talk is the first of four which report recent large-plasma experiments conducted at Livermore. In these experiments, the Novette laser irradiated thin foil targets to produce plasmas with longitudinal scalelengths that were thousands of times the laser wavelength. Laser-plasma interactions in such plasmas are an important forefront in laser-plasma research. In such plasmas the thresholds for several instabilities become smaller and more growth lengths are available for sidescatter processes. In addition, the plasmas in future high-gain implosion experiments will be larger than those easily produced now. Several experimental groups have begun to produce and explore such plasmas.

The Novette experiments are the first to irradiate such large plasmas with 3 to 4 kJ of 0.53 μm light at intensities of order 10^{15} W/cm^2. The laser beam was converging toward the target and the spot size was varied from 450 to 900 μm. The targets were 1 to 3 μm thick CH foils and 0.1 to 0.2 μm thick Au foils. Some of the CH foils were doped with 2 atomic % Si or S, to allow measurement of x-ray line emissions. The Si or S was confined to a 300-μm diameter area in the center of the target, to minimize the effect of radial gradients in density and temperature on the x-ray emissions.

Several measurements were sensitive to the plasma density or temperature, including the x-ray line emissions, the Raman spectrum as a function of time, the absolute magnitude of the bremsstrahlung emission, the timing of the transmitted $3/2\omega_0$ and green light, and possibly other features of the optical spectra. These measurements make possible detailed comparisons of these experiments with LASNEX predictions or simple models.

These long-scalelength plasmas also produced copious Raman scattering, as measured by an array of absolutely calibrated photodiodes. The Raman wavelength corresponds to scattering from densities well below quarter-critical, and little scattering was observed in the forward direction. Several shots produced Raman light yields in excess of 5%. In contrast, the scattering at $3/2\omega_0$ was comparable in the forward and backward directions, but the yields were well below 0.1%.

*This work performed under the auspices of USDOE by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48.

Optical Spectroscopy from Thin Foil Targets*

R. E. Turner, R. P. Drake, D. W. Phillion,
K. G. Estabrook, B. F. Lasinski, R. E. Ellis,
W. L. Kruer, and E. M. Campbell

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

We present in detail the time-resolved optical spectroscopic measurements obtained during Novette (0.53 μm, multi-kilojoule) laser irradiations of thin foil targets. We concentrated on stimulated Raman scattering (SRS) and the 3/2 harmonic emissions. These targets produced significant SRS signals (over 1% of the laser energy) in the backwards (toward the laser) direction. Thin targets irradiated at high intensities produced SRS spectra whose maximum wavelength decreased in time, consistent with the target expanding to densities well below quarter-critical. For slightly thicker foils, the SRS spectra was not unlike the results obtained from solid disk targets. Several attempts were made to record time-resolved SRS spectra in the forward direction; no light was detected, indicating levels below 10^{-6} of the laser energy. The 3/2 harmonic data from these foil targets can be summarized as follows: for the thicker targets, the emission was similar to that obtained from disks, namely, spectrally symmetric red and blue shifted peaks, and a time history similar to the laser's. For the thinner targets, which we believe 'burned thru' to below quarter critical density, the emission was observed to occur in a temporally narrow pulse. In addition, the spectra was no longer symmetric about the exact 3/2 wavelength; the red shifted peak was decidedly broader than previously. Finally, in the forward direction, at 135° from the laser axis, we observed both the red and blue shifted peaks, in agreement with the results reported at last year's meeting.[1]

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

1. W. Seka, L. M. Goldman, M. C. Richardson, K. Tanaka, R. Short, E. A. Williams, Paper A10, 13th Anomalous Absorption Conference, Banff, Canada (1983).

Hydrodynamic Expansion of Thin Foil Targets*

D. W. Phillion, R. L. Kauffman, K. G. Estabrook,
R. E. Turner, R. P. Drake, E. M. Campbell, B. F. Lasinski

Lawrence Livermore National Laboratory
Livermore, CA 94550

The time-dependent density profiles along an axis parallel to the laser beam were measured by looking edge-on and time-resolving the imaged 4 eV bremsstrahlung light. Estimates of the times the foils went through the critical and quarter-critical electron densities are obtained from the time dependence of the transmitted laser light and the $3\omega/2$ light, respectively. These results will be compared with x-ray spectroscopy measurements and computer simulations. The density profile information is needed for interpretation of the laser-plasma instability measurements presented in talks by R. P. Drake and R. E. Turner.

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

X-ray Spectroscopy From Doped Thin Foil Targets*

R. L. Kauffman, R. W. Lee, B. L. Whitten, R. P. Drake,
R. E. Turner, K. G. Estabrook, B. F. Linski, D. W. Phillion,
S. A. Letts, and E. M. Campell

Lawrence Livermore National Laboratory
Livermore, CA 94550

Plasma parameters of thin exploding foils are investigated using x-ray spectroscopy. The center region of CH foils have been seeded with sulphur (S) as an x-ray line diagnostic tracer. By only doping the center region, the effects of lateral density and temperature gradients on the x-ray spectrum are minimized. The S concentration is only 2% atomic of the total emission. This concentration does not significantly change the hydrodynamics of the CH foil and reduces the S line opacities. The S k series lines are time-resolved, using a streaked crystal spectrograph. The first two series members of the Hydrogen-like and He-like resonance lines are observed. These lines are analyzed to infer plasma temperatures. The resolution of the spectrograph is not sufficient to resolve the He-like intercombination line from the resonance line, although some unfolding may be done to use these lines to infer plasma densities. Examples of the data as well as preliminary analysis will be presented.

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

REFLECTIVITY FROM STIMULATED BRILLOUIN BACKSCATTERING FOR A BROADBAND INCIDENT LIGHT*

A. Bortuzzo-Lesne , G. Laval and D. Pesme

Centre de Physique Théorique, Ecole Polytechnique,
91128 Palaiseau - Cedex - France.

The anomalous reflectivity of a bounded plasma is investigated analytically in the case of a broadband incident wave ; the regimes of supersonic and subsonic flows are both considered. The existence of a multiple scattering regime and its consequence upon the reflectivity is studied with respect to the spectral bandwidth of the incident light.

* Work performed under the auspices of C.N.R.S. and Ecole Normale Supérieure de Jeunes Filles.

14th Annual Anomalous Absorption Conference

Experimental Tests of Induced Spatial Incoherence*

S.P. Obenschain, F.C. Young, R.R. Whitlock, J.A. Stamper,
B.H. Ripin, M. Pronko, E.A. McLean, C.K. Manka,
R.H. Lehmberg, S. Kacenjar, M.J. Herbst, J. Grun and S.E. Bodner

Laser Plasma Branch
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Naval Research Laboratory
Washington, DC 20375

We report progress in experiments that test the feasibility of using induced spatial incoherence (I.S.I.) to achieve highly uniform illumination of targets by a high energy laser. In the I.S.I. technique a broadband laser beam is broken up into numerous independent beamlets, which are then overlapped onto a target by a lens.[1] The interference pattern due to the overlapped beamlets averages out on time scales long compared to the laser coherence time to produce a smooth profile. However, the combination of laser bandwidth and instantaneous focal nonuniformity raises the concern that the laser-plasma interaction may be modified. We have been developing the hardware necessary to conduct tests of the effects I.S.I. may have on this interaction. Our initial experiments will utilize a single-beam of the Pharos II glass laser with $E \leq 140$ J, 3 nsec pulse lengths and adjustable bandwidth with $\Delta\omega/\omega \lesssim 0.3\%$. The 18-cm diameter laser beam is converted into several hundred 1-cm square beamlets by means of reflective and transmissive echelon structures. This modified beam will be focused onto targets with intensities near 10^{14} W/cm^2.

*This work was supported by the U.S. Department of Energy and the Office of Naval Research.

1. R.H. Lehmberg and S.P. Obenschain, Optics Comm. 46, 27 (1983).

SESSION B

Raman and $2\omega_p$ I (oral)

Monday, May 7
6:30 p.m.—7:45 p.m.

Chairman: B. Lasinski (LLNL)

A New Model of Raman Spectra in Laser Produced Plasma*

Albert Simon[a] and Robert W. Short

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University of Rochester
Rochester, NY 14623, USA

Abstract

Some experimental observations of Raman scattering in laser produced plasma have been previously attributed to the onset of the convective Stimulated Raman Instability (SRS-C). This interpretation has had a number of difficulties, associated with the calculated threshold for onset of the SRS-C, the existence of gaps in the frequency spectrum near the incident frequency ω_o and near $\omega_o/2$, and with the angular distribution.

We now propose a new explanation based on ordinary incoherent Thompson scattering, with a greatly enhanced "plasma line". Transient local reversed-slope velocity distributions in the underdense region can be produced by pulses of hot electrons arising from the two-plasmon $(2\omega_p)$ or absolute stimulated Raman instabilities (SRS-A) occurring near the quarter critical surface. A simple model yields the observed spectral gaps near ω_o and near $\omega_o/2$. It also explains the correlation of onset of this scattering with onset of the SRS-A, its transient localization in frequency and time, and the weak azimuthal angular variation. The existence of "upscattered" light is also predicted.

*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.

[a] Also at Department of Mechanical Engineering, University of Rochester, Rochester, NY 14627.

Electron Plasma Wave Production by Convective SRS

H. A. Baldis, C.J. Walsh and D.M. Villeneuve

National Research Council of Canada
Division of Physics
Ottawa, Ontario, Canada

We have used temporally- and spectrally-resolved Thomson scattering in a CO_2 laser plasma interaction experiment to identify electron plasma waves driven by stimulated Raman scattering (SRS). Two geometries of preformed plasma were used. In the first, the plasma density was approximately gaussian along the laser axis, with a peak density which was varied between 0.01 n_c and 0.5 n_c; Thomson scattering was performed in a region of 400 μm around the peak. In the second, the plasma density was exponential, with a peak density greater than n_c.

Electron plasma waves were observed only in the gaussian geometry, and only in the density range $(0.01\text{-}0.05)n_c$, with intensities as low as 3×10^{13} W/cm^2. No SRS from below $n_c/4$ was seen with intensities up to 2×10^{14} W/cm^2. These thresholds are in agreement with convective growth rate calculations, since the gain length is larger in the gaussian geometry.

The plasma waves appeared early in the laser pulse, and disappeared as soon as ion waves from SBS appeared. This may explain the absence of SRS at densities between 0.05 n_c and 0.25 n_c.

k-resolved Measurements of Plasma Waves from SRS

D.M. Villenueve, H.A. Baldis, and C.J. Walsh

National Research Council of Canada
Division of Physics
Ottawa, Ontario, Canada

In order to look for the presence of plasma waves produced by absolute stimulated Raman scattering (SRS) near the quarter-critical surface, the Thomson scattering geometry was arranged to provide k-resolved measurements of plasma waves parallel to the pump k_o. The spectrum was found to be centered near k_o and of fairly narrow extent, consistent with production by absolute SRS.

We have also studied the emission of light in the 12-20 μm range, and found most of the light was near 13-14 μm, corresponding to a density of 0.01-0.05 n_c. This is consistent with spectrally resolved Thomson scattering measurements of the plasma waves which indicated that SRS was only occurring in that density range. The narrow wavelength range is due to the short SRS gain length in the gaussian shaped plasma.

The amount of SRS light was found to be strongly dependent on whether the quarter-critical surface was present in the preformed plasma. This is an indication of profile steepening by the two-plasmon decay (TPD) instability, and indicates competition between TPD and SRS.

abstract for the 14th annual anomalous absorption conference

INFLUENCE OF RAMAN SCATTERING ON HALF INTEGER HARMONICS IN A 1.06 μm LASER PRODUCED PLASMA

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Half integer harmonics produced during the interaction of a 1.06 μm laser (at a laser irradiance of 10e16 W/cm^2) with a plane target are analysed. Backscattered and sidescattered (perpendicular to the laser axis) emission are reported and discussed.

We observe that the spectrum of the backscattered convective Raman emission, which is polarized, has a minimum around 0.23 n_c while the sidescattered emission has a maximum at this wavelength, showing the importance of cavitons in the density profile around $n_c/4$.

The analysis of 3/2 and 5/2 harmonics shows that the side-scattered convective Raman emission produces a broadening of the blue line of 3/2 and 5/2 spectra and is responsible of a complementary red line.

RAMAN SCATTERING IN A NEARLY RESONANT DENSITY RIPPLE*

Francis F. Chen and Hugh C. Barr†
University of California, Los Angeles

When stimulated Raman scattering occurs in a plasma that already has a rippled density due to Brillouin scattering, we have previously shown[1] that mode coupling by the ripple causes damping of the Raman-excited plasma wave by putting its energy into nearby harmonics. Since in an underdense plasma k is nearly $2k_o$ for both the ripple (ion wave) and the plasma wave, there is strong coupling to the mode $k \simeq \omega_p/c \simeq 0$ and then to $k \simeq -2k_o$. These three modes dominate the spectrum and are comparable in magnitude even for a small ripple amplitude. A curious result is that the $k = -2k_o$ mode can be larger than the driven mode at $k = 2k_o$. We now understand the physical mechanism: to accommodate the changing density, the plasma wave has to have a spatially varying phase shift with a periodicity equal to the ripple wavelength. When the k-mismatch is sufficiently large, the phase shift causes the wave to look like it is propagating backwards. Depending on the relative size of the ripple and the k-mismatch, there is a standing wave component which causes the wave amplitude to become small and spill out some of the trapped electrons. However, these electrons are still trapped in a long-wavelength potential at the beat wavelength characteristic of forward scatter. We show computations of frequency, growth rate, and k-spectrum from a kinetic code.

* Supported by NSF Grant ECS-83-10972 and Lawrence Livermore National Laboratory order number 2446905.

† Permanent address: University of North Wales, Bangor, U.K.

1 H. C. Barr and F. F. Chen, 1982 Anomalous Absorption Conference, Santa Fe, N.M.

SESSION C

Raman and $2\omega_p$ II (poster)

Monday, May 7
8:00 p.m.—10:00 p.m.

DETECTION OF HIGH FREQUENCY INSTABILITY THROUGH THE SATELLITES OF A HE II LINE*

Behrouz Amini and Francis F. Chen
University of California, Los Angeles

An oscillating electric field in a plasma with a frequency ω can exchange energy quanta of $\pm\hbar\omega$ (or $n\hbar\omega$, where n is an integer) with the surrounding ionized atoms. Information on this energy exchange will be carried by photons emitted in radiative transitions of the ionized atoms. This will lead to new spectral lines--"satellites"-- located symmetrically on either side of the pertinent optical transition and spaced apart by the frequency ω. Though satellites have been seen on forbidden lines of neutral atoms, this is the first time they have been seen on the allowed line of a hydrogen-like atom.

In applying this technique to the 4686 Å line of ionized helium, we have measured very accurately the frequency of an instability in our plasma device which we could have not detected otherwise. The nature of the observed instability is believed to be a two-stream instability between the ions and electrons.

This technique is not restricted to low-temperature and low-density plasmas and provides a potentially powerful and less expensive tool for the detection of an oscillating field in a restricted volume. Application of this technique to an arbitrary ionized atom, like an impurity atom, will be discussed.

* Supported by NSF Grant ECS-83-10972 and Lawrence Livermore National Laboratory order number 3446905.

Energy balance and temperature in a CO_2 laser produced plasma

by

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Abstract

An underdense CO_2 laser produced plasma is experimentally investigated to determine the electron temperature explained in terms of an energy balance. Soft x-ray diagnostics measure a 300 eV thermal and a 2000 eV suprathermal temperature. Ulbricht integrating sphere measurements along with interferometric data for the electron density indicate sufficient laser energy absorption to attain T_e of the order of 600 eV. A novel method of analysis of streak records of the radial expansion is implemented where the conditions of a Chapman-Jouguet detonation wave are applied to allow an independent determination of the thermal plasma temperature and absorbed energy. The observed thermal T_e is found to be consistent with linear inverse bremsstrahlung absorption using the measured degree of absorption provided by the Ulbricht sphere. The energy balance along with the x-ray obtained spectrum allows an estimation of the fraction of suprathermal electrons and appears to be 30%. These electrons can be ascribed to be the result of wavebreaking of the parametric instabilities SBS, SRS, and TPD that are observed in this interaction.

THE $2\omega_{pe}$ INSTABILITY FOR LOW TEMPERATURE, INHOMOGENEOUS PLASMAS*

Celso Grebogi** and Wallace Manheimer

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The fluid equations for the $2\omega_{pe}$ instability in an inhomogeneous plasma are formulated. The solutions are calculated numerically in the cold plasma limit ($k < k_L$, $I \lesssim 4 \times 10^{14}$ W/cm^2). Results are given for profiles recently measured at NRL.[1] Also unstable regions are mapped out as a function of irradiance, scale length and laser wavelength.

1. F. Young, et al., this conference.

* Work supported by DOE
** Permanent address: Univ. of Maryland, College Park, MD 20742

LASER PLASMA COUPLING IN LONG SCALE LENGTH, HIGH Z PLASMAS*

W. L. Kruer, Kent Estabrook and B. F. Lasinski

Lawrence Livermore National Laboratory

W. C. Mead

Los Alamos National Laboratory

Abstract

In long scale length, high Z plasmas irradiated with short wavelength laser light, the collisionality of the plasma can strongly influence the coupling. Significant inverse bremsstrahlung absorption is expected at densities much less than the critical density, a regime not commonly encountered in laser experiments to date. Instabilities near one-fourth the critical density can be suppressed, and various instabilities at lower densities weakened. We discuss this collisional regime, including the effects of self-focussing and filamentation due to the thermal mechanism.

*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.

ANALYSIS OF NOVETTE DISC IRRADIATIONS*

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

Lawrence Livermore National Laboratory

Abstract

A series of well-diagnosed gold disc irradiations has been performed at the Novette laser facility with 2 - 4 kilojoules of 0.53 micron light at 1 ns pulse length. For incident intensities in the 10^{14} to 10^{16} W/cm^2 range, the absorption inferred from scattered light measurements is of order 70 to 80%. Significant levels of Brillouin and Raman sidescatter were detected. The hot electron fraction correlates with Raman scattering for these irradiations, with yields of both larger than 1%. The measured hot electron temperature agrees with that inferred from the phase velocity of Raman scattered plasma waves at ~ $0.1n_c$. The corona conditions inferred from these measurements will be compared to the description of the underdense plasma provided by LASNEX calculations. The dependence of these results on target material, pulse length, and frequency will also be discussed.

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

HALF HARMONIC LIGHT SPECTRA PRODUCED BY TWO-PLASMON DECAY

L. V. Powers and R. L. Berger

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ABSTRACT

We consider the production of harmonic light spectra due to two-plasmon decay in weakly inhomogeneous plasma. The plasma is considered to be one-dimensional and planar. The harmonic light is assumed to be produced by the beating of the laser light with the density fluctuations associated with the Langmuir waves. The 5/2 ω harmonic light has a different polarization dependence than the 1/2 ω and 3/2 ω because it is produced by the 2 ω component of the electron velocity in the laser field mixing with the Langmuir waves. We will emphasize the scaling of the shifts of the red and blue peaks from exactly half-harmonic as a function of electron temperature.

Raman Side-Scattering in Laser Produced Plasmas

C. R. Menyuk and N. M. El-Siragy
University of Maryland

W. M. Manheimer
Naval Research Laboratory

The equations governing Raman side-scattering in laser produced plasma are desired. The threshold pump power as a function of position in the plasma is then determined numerically. The variation of the growth rate with increasing pump power is also determined at some particular locations.

PLASMA SIMULATION STUDY OF STIMULATED RAMAN SCATTERING

G. BONNAUD and C. REISSE

COMMISSARIAT A L'ENERGIE ATOMIQUE
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Stimulated Raman scattering is studied in 1 D 1/2 particle simulations, in which the incident electromagnetic wave is coherent non monochromatic or incoherent . In order to obtain such a wave, different techniques are used : multiple lines (ML) and random phase /1/ /2/ . We observe growing rates and suprathermal electron production with respect to the laser bandwidth and the density profile, with fixed ions and mobile ions . For ML irradiation of inhomogeneous plasmas, each line is resonant ; for sufficient intensity, resonance at very low density can create very energetic electrons by forward Raman scattering, although scattering is reduced at quarter critical density ; this mechanism is a drawback for ML irradiation .

/1/ . Estabrook, Kruer, Lasinski, Phys. Rev. Lett. 45, 1399 (1980)

/2/ . Estabrook, Kruer, Phys. Fluids 26, 1892 (1983).

SPOTSIZE EFFECTS ON RAMAN SIDESCATTER*

B. Afeyan+ and E. A. Williams++

Abstract

The convective amplification of a noise source by a parametrically unstable inhomogenous medium can be calculated by treating the coupled modes in the geometric optics approximation, provided that the amplification region is located far from the turning points of the modes. In this situation localised growing eigenmodes typically do not occur.[1] Conversely, when the unstable region encompasses the turning point of a product wave, such eigenmodes can exist. Nevertheless, if the unstable region is finite in the lateral direction such modes are not guaranteed to dominate over convectively amplified wavepackets.

In the case of Raman sidescattering, both localised and convective modes exist. With a finite laser spot size, two competing effects may limit the gain of a linearly saturated instability: refraction of the initial perturbation out of the interaction region and convection in the lateral direction. Mostrom[2] has considered this for a source localised in density and time and for a normally incident pump. We extend this work to more realistic noise source models which are also localised in the transverse direction, and to obliquely incident pumps, with the aim of predicting the Raman sidescattered light spectrum from a finite plasma in the linear growth regime.

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++Lawrence Livermore National Laboratory, Livermore, CA

*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.

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.

1. M. N. Rosenbluth, Phys. Rev. Ltrs. <u>29</u>, 569 (1972).
2. M. Mostrom, PhD. Thesis, U.C. Berkeley.

SESSION D

Hot Electrons and Ions (oral)

Tuesday, May 8
8:30 a.m.—12:15 p.m.

Chairman: D. Forslund (LANL)

TRAPPED ELECTRON INSTABILITY IN LASER FUSION

M. A. True

KMS Fusion, Inc., Ann Arbor, MI 48106

ABSTRACT

Given a localized potential well around the critical density, the hydrodynamic flow amplifies the potential well. The positive feedback is due to electron trapping in the potential well. The trapped electrons are a collisionless subset of the hot electrons created by the laser at the critical density. A density dip separates the trapped electrons from the cold electrons in the high density interior, and the flux of hot electron energy to the interior is reduced. We investigate the causes of the initial potential perturbation and the growth rate of the trapped electron instability.

ANOMALOUS ABSORPTION AND HOT ELECTRON PRODUCTION

W. Rozmus, W. Tighe, A.A. Offenberger
Department of Electrical Engineering
University of Alberta
Edmonton, Alberta, Canada
and
Kent Estabrook
University of California
Lawrence Livermore National Laboratory
Livermore, California, U.S.A.

ABSTRACT

Several aspects of ion-acoustic decay (IAD), oscillating two-stream (OTS) instabilities and anomalous absorption on ion-acoustic fluctuations are analyzed by theory and particle simulations for underdense, homogeneous plasma ($0.5 < n_e/n_{cr} < 0.8$). For IAD and OTS linear theory is reviewed and compared with simulation results. A nonlinear mechanism for saturation of IAD (OTS) is proposed based on second harmonic generation of ion-acoustic waves.

A simple model in which particles move in the fields of coherent waves related to IAD (OTS) is proposed in order to explain hot electron generation. If the wave amplitudes exceed a certain threshold, large scale stochasticity (LSS) develops - allowing appreciable momentum transfer to particles. The appearance of characteristic Maxwellian tails, observed in particle-in-cell simulations, is related to LSS in particle motion. This result is substantiated by performing simple simulations with 500 particles moving in fixed external fields modelling IAD (OTS). The method presented here should also be useful for analyzing hot particle production through other parametric instabilities (TPD, SRS).

ORAL SESSION

TWO-DIMENSIONAL HYBRID SIMULATION OF SUPRATHERMAL ELECTRON TRANSPORT*

R. J. Mason

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Los Alamos National Laboratory
Los Alamos, New Mexico 87545, U. S. A.

The two-dimensional hydro-transport code ANTHEM has been used to model electron transport in foil-like CO_2 laser fusion targets. ANTHEM treats the suprathermals as either a hot fluid or as collisional PIC particles. The suprathermals scatter against background fluid ions and drag against background fluid electrons. The thermal electrons can be strongly collisional, experiencing friction with the ions, and undergoing Joule collisional heating, heating from the deposited suprathermals, and flux-limited heat conduction. The electrons and ions move in self-consistent E- and B-fields computed by the Implicit Moment Method. ANTHEM has been applied to multi-foil configurations in which the initial temperature and density are both longitudinally and radially dependent. In some instances an initial B-field is present. Suprathermals penetrating the target can lead through the resultant self-consistent fields to return-current patterns strongly dependent on details of the internal target conditions. Discussion will be given to the possible utility of such initial inhomogeneities and fields on the efficient down-conversion of suprathemal energy into localized thermal electron energy.

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

ABSTRACT FOR THE 14th ANOMALOUS ABSORPTION CONFERENCE
MAY 6-11 1984, Charlottesville, VA

FAST ELECTRONS FROM LOCALIZED STRONG COHERENT TRAVELLING WAVES

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The production of fast electrons by localized travelling electrostatic waves will be discussed, with special attention paid to the effect of the input parameters (temperature of the incoming electrons, the trapping parameter (~ transit time/trapping time)) on the fast electron output (relative number of fast electrons, hot "temperature", energy width of hot tail). The relation to the quasilinear diffusion operator will also be discussed.

ENERGY BALANCE EXPERIMENTS ON ANTARES*

J. F. Kephart, D. Bach, G. E. Eden, S. J. Gitomer,
P. D. Goldstone, R. Kristal, C. Mansfield, and M. A. Yates

University of California
Los Alamos National Laboratory
Los Alamos, NM 87545

The Antares laser has recently begun operation at Los Alamos. Operating at a 10 micron wavelength, it has produced 1 ns pulses on target with an energy of 20 kJ. The pulse is delivered in 24 independently focused beams which can be made simultaneous to within about 100 ps rms. The individual beams focus with an f/6 cone and produce a spot diameter of about 200 microns. Focused laser intensities in the range 10^{15} to 10^{16} W/cm^2 can be achieved.

The first target physics experiment on Antares has begun. It is designed to measure hot electron temperature, absorption and fast ion loss on spherical targets. The purpose of this experiment is to test the scaling previously obtained at lower energy (Helios) and help determine the utility of the CO_2 laser as an inertial fusion driver.

The diagnostic complement used in these experiments includes: (1) a calorimeter array used to measure laser absorption and fast ion losses, (2) a multichannel hard x-ray filtered scintillator-photodiode system, used to determine hot electron temperature from the x-ray bremsstrahlung spectrum, (3) x-ray pinhole cameras, (4) fastest ion detection system, and (5) a multichannel filtered XRD soft x-ray detection system used to determine brightness temperature.

A variety of target types are being used in the first experiment. These include high and low Z solid targets with diameters up to 5 mm and spherical shells with thicknesses in the range 1 to 5 microns. Targets are illuminated using both focused and defocused conditions.

Experimental data on hot electron temperature, laser light absorption and fast ion loss will be presented. These data will be compared with results previously obtained with smaller lasers.

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

T_{hot} Studies with Defocused Laser Beams and Large Spots

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University of California
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We had previously studied the variation of T_{hot}, the hot electron temperature, with laser intensity [1, 2]. The variations were implemented for tightly focused laser beams by varying the laser energy, or by varying the laser spot size [1, 2]. We had found in those studies that T_{hot} varied like the squareroot of the incident laser intensity. In the present study I kept the spot size large (120 micrometers diameter), and I varied the incident laser beam energies on the HELIOS laser system. I found that the hot electron temperature, as derived from the x-ray spectral distribution, was proportional to the laser intensity, and that beyond a certain intensity the yield of hot electrons generated x-rays increased very sharply, indicative of some unstable processes that enhanced the absorption.

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[1] G. A. Kyrala and D. Bach, LA-UR-82-305
[2] W. Priedhorsky et al., Phys. Rev. Lett. 47, 1661 (1981)

abstract for the 14th annual anomalous absorption conference

IMAGING OF HOT ELECTRONS PRODUCED BY PARAMETRIC INSTABILITIES IN A 1.06 μm LASER CREATED PLASMA

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At high laser intensities,very energetic electrons are produced by two plasmons decay and by Raman scattering. We analyse the emission zones of the electrons produced by these parametric instabilities for a 1.06 μm laser produced plasma. Various filtered pinhole cameras are used at different angles on planar targets to spatially characterize the hot electrons emission for laser irradiance between 10e15 W/cm^2 and 10e16 W/cm^2. Results obtained under various incident conditions will be presented and discussed.

Search for Very High Energy Electrons in an Underdense CO_2 Laser Plasma*

D. R. Bach, M. A. Yates, D. E. Casperson,
D. W. Forslund, J. S. Ladish, F. B. Harrison, and K. R. Winn

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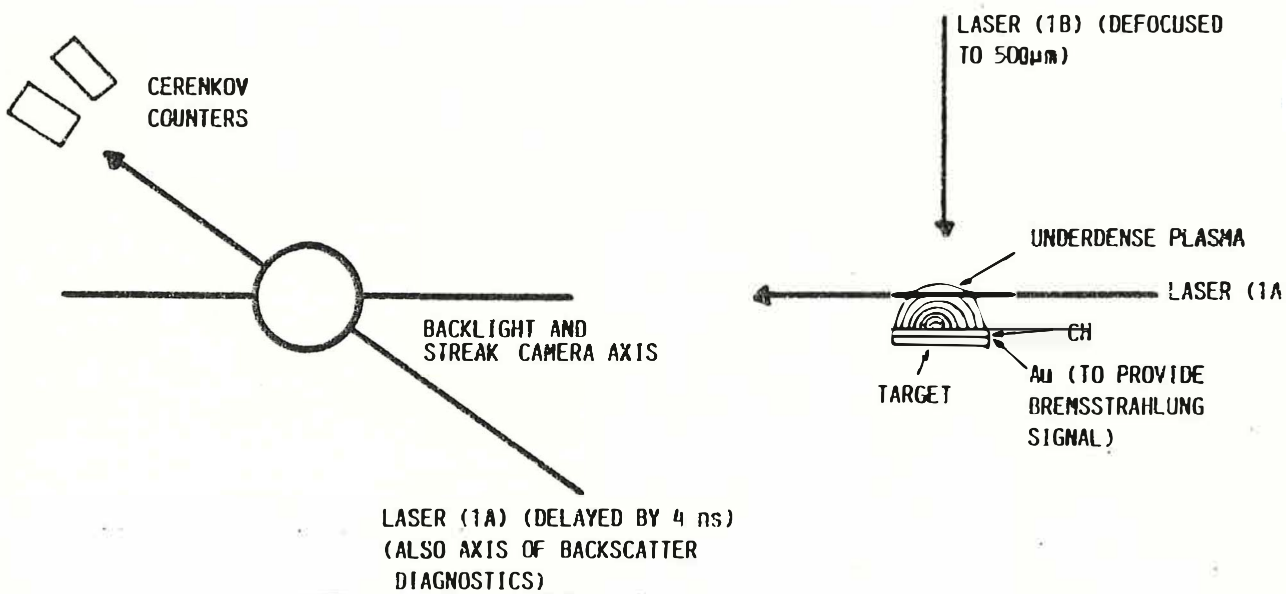
ABSTRACT

As a preliminary experiment in a series designed to investigate the laser beat accelerator concept,[1] we have looked for high energy electrons in an underdense plasma using a single wavelength beam of the Helios laser system.

The plasma was preformed using a beam defocused to a 500 μm spot on a CH target, and the interaction laser beam was delayed by 4 ns (Fig. 1). In addition to the standard Helios diagnostics, two Cerenkov counters were placed as shown with thresholds set to detect electrons with energies above 15 MeV. Plasma density was varied by changing the position of the target surface relative to the delayed beam, so that densities varying from well above to well below critical could be scanned. Backscatter diagnostics were available so that the 2ω and $3/2\ \omega$ signals could be monitored. A careful search for high energy electrons was made at a density between critical and $n_c/4$ with a null result, i.e., fewer than 10^4 electrons with energy >15 MeV were obtained for an incident laser energy of ~ 600 J. Simulations which aid in the interpretation of this experiment will be reported in an accompanying paper.[2]

[1]T. Tajima and J. M. Dawson, Phys. Rev. Lett. 43, 267 (1979).
[2]J. M. Kindel and D. W. Forslund, Filamentation, Self-Focusing and Hot Electrons.



SIDE VIEW TOP VIEW

Fig. 1

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

Time resolved measurements of two plasmon decay waves correlated to fast electron generation in CO_2-laser-plasma interactions

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Dept. of Physics, The University of British Columbia
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Large amplitude two plasmon decay fluctuations generated by CO_2-laser radiation incident on a N_2 gas jet target are investigated by ps-resolution Thomson scattering of ruby laser light. Both the spatial and wave vector evolution of two of the four decay waves is measured by suitable imaging of the scattered radiation onto the slit of a streak camera. The instability is seen to appear in bursts of 20 to 40 ps duration appearing at more or less regular intervals corresponding to an ion acoustic period. The fluctuations start over a range of wave vectors $3.5 < k_y/k_0 < 1.5$ and then rapidly evolve to shorter wave numbers while the spatial range of the scattering region rapidly narrows indicating profile steepening. Fast electrons generated by the observed decay wave are measured concurrently with the Thomson scattering and the correlation of their energy distribution and number to the observed fluctuation parameters is reported.

FAST ION IMAGING WITH A PINHOLE CAMERA ON CO_2-LASER PLASMAS

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D. Pascale, J.-C. Kieffer, H. Pépin, P. Lavigne
Institut national de la recherche scientifique - Energie
Varennes, Québec, Canada

Pinhole imaging of the fast ion emission is used to correlate spatially the hot electron transport with the energetic ion emission and also to determine the direction and cone angle of the ion emission from various regions of the target surface. Space charge expansion of the ion beam beyond the pinhole is minimized by adjusting the ion energy filtration, the camera magnification and the target-to-pinhole distance. Experimental techniques have also been developed to verify in situ the spatial resolution at the image plane.

Pinhole images of the fast ion emission have been obtained for planar CO_2 laser illumination of various target material in the range from 5×10^{13} W/cm^2 to 3×10^{14} W/cm^2. Images from various observation angles and energy filtrations are required to characterize the emission. In general, the fast ion emission occurs over a region comparable to the lateral hot electron transport zone (few mm). Strong emission is observed near or within the focal spot for lower energy ions only. Other features of the ion emission will be presented and related to the electron transport.

Fast Ion Emission in Laser Matter Interaction Theory and Experiment*

Steven J. Gitomer and Roger D. Jones

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Data on emission of energetic ions produced in laser-matter interactions has been analyzed for a wide variety of laser wavelengths, energies and pulse lengths. Strong correlation has been found between the mean energy per AMU for fast ions as determined by charge cups and the X-ray determined hot electron temperature (Refs. 1 & 2).

In order to elucidate the physics of what appear to be three distinct parameter regimes in the data, we have done extensive theoretical modelling using a large scale hydro code. Results of the scaling obtained from our modelling will be presented.

REFERENCES

[1] S. J. Gitomer, R. D. Jones, F. Begay, A. W. Ehler and J. Kephart, 1983 IEEE International Conference on Plasma Science, San Diego CA, IEEE Conference Record 83CH1847-3, paper 2A4, page 30.

[2] S. J. Gitomer and R. D. Jones, Bulletin of the American Physical Society 28, 1084 (1983).

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

PHYSICS OF THE LASER-PLASMA INTERACTION AT A LOCAL MAXIMUM OF THE PLASMA DENSITY

Thomas Speziale
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ABSTRACT

The absorption and scattering of laser light by a plasma are strongly influenced by the density gradient that the light encounters. Laser-plasma experiments that employ thin foils produce plasmas with a local density maximum and, hence zero gradient, once burnthrough has occurred. We examine the behavior of several physics processes in the vicinity of a local maximum of the density including resonance absorption, Raman scattering, inverse bremsstrahlung, and beat-heating with dual frequency illumination. Of these processes, Raman scattering and inverse bremsstrahlung can occur at any time after burnthrough and we estimate the effective scattering and absorption lengths associated with them due to the finite width of the density maximum. Resonance absorption and beat-heating (with 1 and 1/2 micron light), however, can occur only over a limited time due to more severe density constraints. We find that sufficient time exists for beat-heating to occur so that a test of the beat-heating concept at high laser intensity may be possible.

THE ROLE OF CAVITON FORMATION IN SATURATION OF PARAMETRIC INSTABILITIES

by

B. Bezzerides, C. Aldrich, and K. Lee
Applied Physics Division

D. F. DuBois, and H. Rose
Theoretical Physics Division

Los Alamos National Laboratory
Los Alamos, NM 87545

We have considered the development and saturation of parametric instabilities for laser fusion applications in a regime of driver strength that has received little attention, i.e., $(v_o/v_e)^2 << 1$, where v_o is the oscillatory velocity in the driver and v_e is the thermal velocity for the OTS instability we have used both PIC and fluid simulations to show that there exists a transition for the saturation from wave-breaking of the linearly excited waves for $(v_o/v_e)^2 >> 1$ to saturation by caviton formation for $(v_o/v_e)^2 << 1$. Results on the heated particle distribution will also be presented. Preliminary results for saturation of stimulated Raman and 2 ω_p in this weak limit of driving will also be considered.

SESSION E

Raman and $2\omega_p$ III (oral)

Tuesday, May 8
6:30 p.m – 7:45 p.m.

Chairman: A. Simon (University of Rochester)

Experiments with Disk Targets Irradiated with 0.53 and 1.06 μm Laser Light

C. L. Shepard, Gar. E. Busch, R. R. Johnson,
R. J. Schroeder, and J. A. Tarvin
KMS Fusion, Inc., Ann Arbor, Michigan 48106

We have performed experiments in which Au disk targets were irradiated simultaneously with 0.53 and 1.06 μm laser light in 1.0 ns pulses. The intensity was typically 4×10^{14} W/cm^2 for 0.53 μm light. For 1.06 μm light, the intensity varied from 5×10^{12} to 5×10^{14} W/cm^2. The experiments were designed to test whether or not "beat heating" of the plasma would produce a significant hot electron population and to see if Raman scattering was enhanced by the presence of 1.06 μm light. In order to facilitate comparison, experiments were done with the beam polarizations either parallel or perpen-dicular with respect to each other. Our measurements show only slight differ-ences in the hot electron fraction, in agreement with calculations. Raman scattering was enhanced only at the 3/2 harmonic of the 1.06 μm light (0.702 μm).[1] The influence of the 1.06 μm light is seen primarily in the 3/2 harmonic spectra of the 0.53 μm light.[2]

References

1. J. A. Tarvin, et al., this conference (Anomalous Absorption Conference).
2. R. J. Schroeder, et al., this conference (Anomalous Absorption Conference).

How useful are odd-integer half-harmonics?*

W. Seka, L.M. Goldman, K. Tanaka, B. Afeyan, A. Simon, R. Short.
Laboratory for Laser Energetics, University of Rochester, Rochester, N.Y.

Odd-integer half-harmonic spectra from laser-produced plasmas have been reported since 1970. They have been clearly identified as related to parametric processes near $n_c/4$, most prominently the $2\omega_p$ decay instability. In this paper we present arguments for the exercise of greater caution in the use of the $3\omega/2$ spectral splitting as a temperature diagnostic. We further discuss a model to explain the various features of the $\omega/2$ spectra and we will show that one of its features is well suited as a temperature diagnostic. Furthermore, we will discuss fine structure observed in both the $\omega/2$ and $3\omega/2$ spectra which appears to be related to secondary decay processes near $n_c/4$.

A number of theories have been developed over the past few years to explain the shifts and splittings observed in the double-humped 3/2 harmonic spectra. They clearly show that for normal incidence the splitting is symmetrical around $3\omega_0/2$ but its magnitude depends on the angle of observation. For oblique incidence the spectra become asymmetrical and and for the general case of oblique incidence and observation under arbitrary angles the results are truly complex. Traditional interpretation of experimental $3\omega/2$ spectra typically ignored these difficulties and temperatures thus inferred are usually rather bad overestimates. As a general rule the splitting of the 3/2 harmonic spectra is difficult to use quantitatively except in special cases where irradiation and observation geometries are well known. This, however, is seldom the case.

The half harmonic spectra obtained from UV laser plasmas have shown structures containing broad double peaks with a superposed sharp spike which is slightly red-shifted with respect to $\omega_0/2$. This sharp feature is the first feature visible at low intensities in spherical irradiation experiments with low-Z targets. Its relative intensity with respect to the broad features decreases with increasing intensity on target. For high-Z targets this spike is difficult to observe. We interpret this feature as due to Raman down-scattering of incident light from "blue" plasmons generated in the $2\omega_p$ decay instability. Due to the very restrictive k-matching conditions for this process this sharp spike has a very well defined red-shift which relates simply to the temperature as $\Delta\lambda^{Å} = 8.8\times10^{-3}\lambda_L^{Å}T^{keV}$. In contrast, the broad features are interpreted in terms of plasmon-photon conversion via inverse resonance absorption. Consequently, the spectral splitting of this double-peaked structure depends not only on temperature but also on the density gradient, the angle of observation and angle on incidence. Thus, this signature is of little diagnostic use.

Recently observed fine structure on the $3\omega/2$ and $\omega/2$ spectra have shown a common beat frequency which can be correlated with specific ion acoustic waves via $\Delta\omega = \omega_{ia} = k_{ia}c_s \approx 2k_0c_s$. This would be indicative of expected secondary decays of plasmons produced by the $2\omega_p$ decay instability. The implications are intriguing as they open the possibility for ordinary Brillouin scattering of incident laser light from those ion acoustic waves.

*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.

Evidence for 2 ω_p decay of 1053 nm light in a gold plasma at 3 x 10^{13}W/cm^2

J. A. Tarvin, R.L. Berger, L.V. Powers, R.J. Schroeder, C.L. Shepard

Abstract for Anomalous Absorption Conference
Charlottesville, VA
May 6-11, 1984
(due March 16, 1984)

Harmonic emission measurements are reported for gold disk targets irradiated simultaneously with 1053 nm and 526 nm light. Emissions at 3/2 ω_r and 5/2 ω_r (ω_r = 2πc/1053 nm) are observed when the 1053 and 526 nm intensities are 3 x 10^{13} and 3 x 10^{14}W/cm^2 respectively. The 3/2 ω_r spectrum has the familiar two-peak structure except that the high-frequency peak is more intense. (In single wavelength experiments, the low-frequency peak of the 3/2 ω spectrum is usually more intense). The 5/2 ω_r spectrum has a structure similar to the 3/2 ω_r spectrum, but the low-frequency peak is more intense. The symmetry of the total spectrum about $\omega_g = 2\omega_r$ suggests that the harmonics are produced by scattering of 526 nm photons from the plasma oscillations resulting from 2 ω_p decay of 1053 nm light. The reversal of the usual intensity ratio of the 3/2 ω_r peaks supports this interpretation.

The density scalelength ($L = n/|\nabla n|$) and electron temperature at n_e = 2.5 x $10^{20}cm^{-3}$ were determined from holographic interferometry[1] to be 65 μm and 1.8 keV, respectively. Consequently, the intensity threshold for 2 ω_p decay of 1053 nm light should be [2] 10^{14}W/cm^2, approximately three times the actual average intensity.

(1) See papers by R.R. Johnson and C.L. Shepard at this conference.
(2) B.F. Lasinski and A.B. Langdon, LLNL Laser Program Annual Report, 1977, p. 4-49.

14th Annual Anomalous Absorption Conference
Charlottesville, Virginia
May 6-11, 1984

OBSERVATION OF SCATTERED LIGHT BETWEEN $\omega/2$ AND $3/2\omega$ IN SHORT WAVELENGTH LASER PRODUCED PLASMAS

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Abstract

Extensive measurements have been carried out on scattered radiation in the spectral region between $\omega/2$ and $3/2\omega$ from plasmas produced by 351 nm lasers. The relative intensities of the continuum radiation relative to the line features at $\omega/2$ and $3/2\omega$ will be shown. A new spectral feature has been observed between $3/2\omega$ and ω which may be interpreted as an upscattered component produced by ordinary Raman scattering. The overall experimental evidence for ordinary Raman scattering vs stimulated Raman scattering will be discussed.

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.

SOME TOPICS IN RAMAN SCATTERING*

E. A. Williams
Lawrence Livermore National Laboratory

Abstract

Stimulated Raman Scattering has been identified as a significant source of hot electrons in long scalelength laser heated plasmas. For thin foil targets one might expect the lowest possible gradient threshold to occur for sidescatter in the vicinity of the density maximum. We investigate this possibility both analytically and numerically.

*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

SBS, Self-Focusing, and Quarter-Critical Processes (Poster)

Tuesday, May 8
8:00 p.m. – 10:00 p.m.

Brillouin scattering in underdense UV laser-produced plasmas.*

K. Tanaka, B. Boswell, R. S. Craxton, L. M. Goldman, M. C. Richardson, W. Seka, R. W. Short, J. M. Soures.

Laboratory for Laser Energetics, University of Rochester, Rochester, New York.

We report on studies of UV laser produced plasma interactions in underdense media. Particular attention was addressed to observation of Brillouin scattering and self-focusing.

These processes were studied in underdense foam targets whose average density is 0.02 g/cm^3 ($n_e \cong 2n_c/3$). The plasma was produced by a single beam UV laser (GDL) with up to 60 J on target and 800 psec pulse duration. The backscattered light was spectrally resolved and its energy was monitored. An x-ray pinhole camera looked side-on at the plasma around 1 keV, providing some evidence for self-focusing.

We observe a fractional backscatter of 6-9 % at a laser intensity of 10^{15} W/cm^2. Furthermore, the backscattered light is strongly collimated and is red-shifted (∿3 Å). These features of the backscattered light are consistent with Brillouin scattering, which has a maximum growth rate in the backward direction. Simulations without any parametric instabilities indicate that very little light would be reflected due to strong absorption from the underdense plasma.

Side-on x-ray images exihibit features indicative of self-focusing in underdense foam targets. The x-ray emission extends 500-600 μm into the target with individual channels of 30-60 μm diameter. These features in the x-ray pictures can be explained assuming that hot spots in the focal area self-focus and propagate independently into the target.

*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.

14th Annual Anomalous Absorption Conference

Nonstationary Thermal and Pondermotive Filamentation of 'Incoherent' Laser Light*

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Transient filamentation of laser light in evolving laser fusion plasmas is examined using a numerical code. Both pondermotive and inverse bremsstrahlung heating mechanisms are considered in the analysis. The code is used to investigate the spatially incoherent illumination scheme[1] which is characterized by rapidly varying time and space fluctuations of the intensity. Previous results[2] indicate that the time averaged pondermotive filamentation alone is not enough to cause significant intensity enhancements. The thermal filamentation of smaller transverse wavelength intensity variations is prevented by the large thermal conduction in the hot plasma, which rapidly smooths out the small scale temperature nonuniformities that begin it. However, filamentation maybe initiated by the longer-lived, longer wavelength thermal fluctuations. This can in turn enhance and drive unstable the pondermotive mechanism, leading to catastrophic break-up of the light. The conditions under which this bootstrapping mechanism can occur are investigated, and the effect of the induced incoherent light is analyzed.

(1). R.H. Lehmberg and S.P. Obenschain, Opt. Comm. 46, 27 (1983).
(2) A.J. Schmitt, Bull. Am. Phys. Soc. 28, 1145 (1983).

*This work was sponsored by the U.S. Department of Energy.
**NRC-NRL Research Associate

REDUCTION OF REFLECTIVITY IN STIMULATED BRILLOUIN SCATTERING DUE TO INCOHERENCY EFFECTS

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The nonlinear evolution of stimulated Brillouin backscattering is investigated with respect to the time coherency of daughter waves, in the case of a monochromatic laser . Both cases of supersonic and subsonic flows are examined . One shows that the steady state of the standard coherent solutions may be destroyed either by a fluctuating noise or by nonlinear effects due to the ion acoustic waves . There exists regimes for which the reflectivity becomes strongly incoherent in time . The time average reflectivity is numerically found greatly reduced as compared with the usual prediction based upon stationary models.

Stimulated Brillouin Scattering in Plasmas with Z>1 and Multiple Z Plasmas

Robert Huff and John M. Dawson
Physics Dept. UCLA

We have been studying stimulated Brillouin scattering in plasma of high Z ions and in plasmas of multi-species ions by means of computer simulation and theory. The presence of high Z ions can greatly lower the threshhold of stimulated Brillouin scatterinng and raise the saturation amplitude. We have seen this effect in 1 2/2 dimmensional fully electromagnetic models. It also shows up analytically because high Z ions greatly reduce the Landau damping of ion waves, since their thermal velocity is much slower than that of the acoustic waves. The normal condition to get weakly damped ion acoustic waves in a Z=1 plasma is that $T_e=10T_i$; for a plasmma with ion charge Z this is replaced by $T_e=10T_i/Z$. Thus for a carbon plasma T_e need only by $1.6T_i$.

Work supported by DOE-Contract DE-AS08-83DP-40190, LLNL University Support Program.

Nonlinear Saturation of the Parametric Instability for Three Coupled Oscillators

by

A. Simon, C.J. McKinstrie and E.A. Williams*
Laboratory for Laser Energetics
University of Rochester, Rochester, New York 14623

Abstract

The case of three parametrically coupled and damped oscillators is considered. One (with natural frequency ω_0) is externally driven at a frequency Ω close to the sum $(\omega_1+\omega_2)$ of the other two. In the vicinity of the parametric instability threshold, we determine the time-asymptotic oscillator amplitudes and nonlinear frequency shifts by using secular-free perturbation analysis. The resulting amplitudes are sensitive to the mismatch δ $(=\Omega-\omega_1-\omega_2)$, if Ω and ω_0 are dissimilar, and rise sharply as $\delta\to 0$. If Ω is close to ω_0, the behavior is quite insensitive to δ, and models results obtained for parametric instabilities in plasma.

The single parametrically-driven oscillator threshold result is also obtained and compared to a general small amplitude result of Landau. This Landau result is then generalized to two coupled oscillators and compared to a result obtained by perturbation analysis. These two cases all behave as the three-oscillator does when ω_0 and Ω are dissimilar. All solutions are shown to be stable.

*Present address: Lawrence Livermore Lab., Livermore, CA 94550.

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.

3/2 ω SPECTRA FROM GOLD DISKS SIMULTANEOUSLY IRRADIATED WITH 526 AND 1053 nm LASER LIGHT

R.J. Schroeder, R.L. Berger, L.V. Powers, J.A. Tarvin, C. Shepard

Abstract for Anomalous Absorption Conference
Charlottesville, VA
May 6-11, 1984
(due March 16, 1984)

Measurements of harmonic light spectra at 3/2 ω_g ($\omega_g = 2\pi c/526$ nm) are reported for gold disks irradiated simultaneously with 526 and 1053 nm laser light. For the single wavelength experiment with 526 nm light, the 3/2 ω_g spectrum has the characteristic two peak structure due to the two plasmon decay process. Harmonic emission at 3/2 ω_g when the 526 and 1053 nm intensities are 3×10^{14} and 3×10^{12} W/cm^2 respectively (1% mixture) exhibit a third structure in the form of an intense spike at 351 nm. The 3/2 ω_g red and blue shifted peaks become severely attenuated with a 10% 1053 nm mix. With equal 526 nm and 1053 nm intensities, only the narrow spike at 3/2 ω_g was observed. In the last two cases, the intensity of the 3/2 ω_g peaks were significantly below what was measured for the single wavelength experiment.

The 3/2 ω_g spike is produced by scattering of the 526 nm light from electrostatic plasma waves produced by resonance absorption of the 1053 nm laser light. Among the possible reasons for the suppression of the 3/2 ω_g spectra with increased 1053 nm intensity is the reduction of the density scalelength at 1/4 n_c or the increase in the damping rate of plasmons. By analysis of the 3/2 ω_g spectra as a fuction of 1053 nm intensity, we obtain temperature and scalelength estimates at 1/4 n_c.

FIRST TESTS OF THE LASNEX 3D RAYTRACE LASER*

Alex Friedman

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

Applications of the new LASNEX three-dimensional raytrace laser package to model problems are described. In particular, a simple parameterized randomization of ray velocities at turning points, employed to model scattering by refraction off density ripples near critical, has been implemented. This model is discussed, and its properties illustrated by application to a simple gold disc test problem.

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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.

14th Annual Anomalous Absorption Conference

Numerical Modeling of Laser Filamentation in Long Scalelength Plasmas*

R. H. Lehmberg, J.A. Stamper, J.H. Gardner,** and M.J. Herbst
Laser Plasma Branch
Plasma Physics Division
Naval Research Laboratory
Washington, DC 20375

**Laboratory for Computational Physics

In a recent experiment,[1] evidence of filamentation was observed in 2ω emission when a short (300 psec) 1.05 μm pulse was tightly focused into a long scalelength plasma produced by a defocused 3 nsec beam of low intensity. At the higher short pulse energies (corresponding to incident intensities ~ 6 x 10^{14} W/cm^2) the emission occurred in highly localized filamentary structures at distances as large as 1 mm from the target. Here, we report numerical simulations of pondermotive filamentation using a steady state 2D propagation code whose initial density and temperature distributions were previously modelled[2] by the NRL FAST2D hydrodynamic code. The simulations show a strong increase of filamentation as the incident short pulse intensity increases from 10^{14} to 6 x 10^{14} W/cm^2. At the highest energy, the beam (70 μm FWHM incident diameter) begins to exhibit whole beam self focusing around 1.5 mm axial distance from the critical surface, then forms a ring structure that collapses to a single 3 μm filament of peak intensity 3 x 10^{17} W/cm^2 at ~ 1.1 mm. The ambient plasma density at these distances is $\lesssim$ 0.025 n_c. Beyond this focus, the ring diverges and breaks up into secondary rings, with peak intensities in the range 10^{15}-10^{16} W/cm^2. We will show the comparison between these results and the observed 2ω filamentation.

1. J.A. Stamper, F.C. Young, M.J. Herbst, S.P. Obenschain, J.H. Gardner, R.H. Lehmberg, E.A. McLean, J. Grun, K.J. Kearney, and B.H. Ripin, Naval Research Laboratory Memorandum Report 5173.
2. M.J. Herbst, J. Grun, J. Gardner, J.A. Stamper, F.C. Young, S.P. Obenschain, E.A. McLean, and B.H. Ripin, Phys. Rev. Let. 52, 192 (1984).

*This work was sponsored by the U.S. Department of Energy.

SESSION G

Thermal Transport (oral)

Wednesday, May 9
8:30 a.m.—12:00 p.m.

Chairman: J. Meyer (University of British Columbia)

14th Annual Anomalous Absorption Conference
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NONLOCAL HEAT TRANSPORT BY NON-MAXWELLIAN ELECTRONS

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Abstract

The generalization of the Spitzer-Harm solution to steep density and temperature gradients requires the computation of the appropriate non-Maxwellian isotropic part of the electron distribution. We develop analytic solutions for a steady state, high-Z plasma, employing the diffusion approximation. Applications of our solution include computation of the resulting heat flux, thermal smoothing of transverse temperature perturbations, and modification of linear heat flow instabilities.

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 Lase Energetics.

HEAT CONDUCTION THROUGH A POTENTIAL BARRIER IN LASER-PLASMA INTERACTION

M.S. Chu, R.W. Harvey, F.L. Hinton, and C.S. Liu
GA Technologies, Inc.
San Diego, California 92138

With laser irradiation of a microsphere, a substantial amount of laser energy is absorbed at the critical layer and quarter critical density layer by resonance absorption and parametric decay processes, and hot electrons are generated there. The electrostatic potential is expected to have a maximum near the source of hot electrons and small values nearby. This potential structure resembles those of thermal barriers in magnetic fusion devices and can effectively reduce the heat flux carried into the microsphere by the hot electrons. A quantitative evaluation of this reduction will be presented for a given potential structure.

Spectroscopic Evaluation of the Heat Front Profile in Laser Plasma Transport Experiments*

A. Hauer, W. Mead, and O. Willi

University of California
Los Alamos National Laboratory
Los Alamos, NM 87545

J. D. Kilkenny

Imperial College
London, England

D. Duston

U. S. Naval Research Lab
Washington, DC

Abstract

Spectroscopic techniques have been used to evaluate the spatial and temporal profile of the heat front in laser plasma transport experiments. Time resolved measurements were made of the x-ray line spectrum from layered spherical targets. The spectrum is modeled by post processing the output of LASNEX hydrodynamic simulations. By changing the characteristics of the hydro modeling and comparing the theoretical and experimental spectra, the nature of the penetration of the heat front to the x-ray radiating layers can be studied. The result is a more detailed picture of the thermal conduction into the target.

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

Electron Transport and Plasma Profiles in 1.06 μm Multilayer Spherical Transport Experiment*

by

W. C. Mead, A. Hauer, O. Willi, and M. Mahaffy,
Los Alamos National Laboratory,
D. Duston, Naval Research Laboratory
and J. D. Kilkenny, Imperial College.

Multilayer (Glass/CH/Al/CH) spherical targets of about 150 μm diameter have been irradiated at 1.06 μm, 1 ns, and 3-8 x 10^{14} W/cm^2 to study axial and lateral transport processes. We present calculations and analysis of the results. We discuss the laser-plasma interactions. We examine time-resolved emission spectroscopy of the Glass and Al layers to infer the penetration and shape of the thermal front. Two dimensional calculations with raytrace propagation of the laser light are used to determine the effects of refraction and nonuniform illumination on the thermal front. We analyze plasma profile measurements obtained using interferometry. The results are compared with expectations based upon theory and detailed transport models.

*Work supported by the U.S.D.O.E.

Prefer oral presentation.

Please place after companion presentation by A. Hauer.

ELECTRON-ION COLLISIONS IN LASER-FUSION PLASMAS*

J. R. Albritton

Lawrence Livermore National Laboratory

Abstract

Electron-ion collisions are considered in partially ionized dense plasmas. A calculation of the laser absorption and electron heat transport coefficients is described. Factors of two are at stake with respect to some more naive treatments. The role of ion-ion screening is emphasized.

*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.

R.S. Marjoribanks, M.C. Richardson, B. Yaakobi, O. Barnouin,
J. Delettrez, R. Epstein, and W. Beich
May 6-11, 1984

TIME-RESOLVED MEASUREMENTS OF THE IONIZATION FRONT IN TRANSPORT STUDIES

R.S. Marjoribanks, M.C. Richardson, B. Yaakobi,
O. Barnouin, J. Delettrez, R. Epstein, and W. Beich
Laboratory for Laser Energetics
University of Rochester
250 East River Road
Rochester, New York 14623

Abstract

Characterization of the ionization front associated with thermal transport in laser-irradiated CH targets, as measured by x-ray emission from imbedded thin metallic layers, will be discussed. Observations of time-resolved filter spectrometry and time-integrated crystal spectroscopy of continuum and line emission from targets uniformly irradiated by the 24-beam 1053 nm and 6-beam 351 nm OMEGA laser will be compared, and contrasted with LTE calculations from the code LILAC; in particular, thin layer experiments suggest an observable competition between rates of ionization and hydrodynamic expansion.

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 Lase Energetics.

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THERMAL TRANSPORT MEASUREMENTS IN SIX-BEAM, UV IRRADIATION OF SPHERICAL TARGETS

O. Barnouin, J. Delettrez, L.M. Goldman, R. Marjoribanks,
M.C. Richardson, J.M. Soures, and B. Yaakobi
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University of Rochester
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Rochester, New York 14623

Abstract

Thermal transport was studied in spherical irradiation geometry, using the six frequency tripled beams on OMEGA. The results were obtained using x-ray line spectroscopy data as well as charge collectors, over the power density range of 10^{14} - 10^{15} W/cm^2. A comparison was made between the results of these two methods of measurement, between 1054 nm and 351 nm irradiation, and between uniform (overlapping beams) and non-uniform (tight focus) irradiation. One of the salient features found is a very large burn-through depth (and burn-through rate) as measured with x-ray radiation from an aluminum substrate. An additional important indication of the transport characteristics is obtained from the final core conditions of imploding shell targets.

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 Lase Energetics.

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NON-LTE CONSIDERATIONS IN SPECTRAL DIAGNOSTICS OF THERMAL TRANSPORT AND IMPLOSION EXPERIMENTS

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Abstract

Recent thermal-transport and target-implosion experiments have used the emission of radiation from highly-ionized ions to signal the advance of laser-driven heat fronts and to mark the trajectories and stagnation points of imploding shells. We examine the results of such experiments with particular attention given to non-LTE effects of non-Maxwellian electrons and of finite ionization times on the populations of signature-emitting atomic species and on the formation of signature spectra and x-ray images in these experiments.

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 Lase Energetics.

SOLUTION OF THE VLASOV-FOKKER-PLANCK EQUATION FOR A LASER-PRODUCED SPHERICALLY-SYMMETRIC STEADILY-ABLATING PLASMA

A R Bell

Rutherford Appleton Laboratory, Chilton, Didcot, Oxon, OX11 OQX, UK

Density, temperature and heat flow profiles in a steadily ablating laser-produced plasma are calculated in spherical geometry by self-consistent solution of the Vlasov-Fokker-Planck equation for electrons and the fluid equations for cold ions. At high laser irradiances, the plasma flow diverges as it flows away from the solid target and the effects of non-planar flow are important. In contrast to similar calculations in planar geometry which show that deviation from the Spitzer conductivity is negligible, the Spitzer conductivity breaks down in spherical geometry. The temperature and density profiles calculated from the Vlasov-Fokker-Planck equation differ significantly from those calculated when the Spitzer conductivity is used to determine the heat flow.

TRANSPORT EFFECTS OF INTERACTING HOT AND COLD ELECTRON POPULATIONS IN STEEP TEMPERATURE AND DENSITY GRADIENTS

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

ABSTRACT

Mechanisms responsible for thermal conduction anomalies in laser heated plasmas will be discussed. A method for extending the Chapman-Enskog solution of the Boltzmann equation to large gradients and fields will be used to investigate the interaction of hot and cold electron populations through the quasineutral electric field. As found by Shkarofsky for small gradients, both density and temperature gradients affect heat conduction in this problem. The present analysis describes heat conduction due to two interacting electron populations in the presence of strong gradients and will be applied to the results of recent experiments.

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LIMITS ON THE FLUX LIMITER AND PREHEAT FROM SIMULATIONS OF EXPERIMENTS ON THE OMEGA SYSTEM AT 1054 nm and 351 nm

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Rochester, New York 14623

Abstract

A lower bound for the flux limiter has been deduced from simulations of two different types of spherical experiments carried out on the OMEGA laser system. In the first experiment DT-filled glass microballoons were imploded with 1 ns pulses of 1054 nm laser light at intensities of 4×10^{14} W/cm^2. Replication of the double-ring structure observed in the x-ray microscope images was sensitive to both the flux limiter and the absorbed fraction in the suprathermal component. In a second experiment plastic spheres were irradiated by 700 ps pulses of 351 nm laser light at intensities ranging from 5×10^{13} to 2×10^{5} W/cm^2 and the simulated mass ablation rate computed from charge collector traces was compared to that measured experimentally for varying values of the flux limiter. Both experiments place a lower limit of $f = 0.03$ on the flux limiter. Also an upper bound at $f \sim 0.07$ and preheat levels consistent with about 20% of the absorbed energy into the suprathermal component can be deduced from the implosion experiment.

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.

Hydrodynamic Calculations of Inhibited Transport Experiments

John H. Gardner and Mark H. Emery
Laboratory for Computational Physics
and Mark J. Herbst
Laser Plasma Branch, Plasma Physics Division
Naval Research Laboratory
Washington, D.C.

An important aspect of our understanding of the interaction of laser energy with matter for inertial confinement fusion application is the question of energy transport from the underdense absorption region to the overdense ablation region. Considerable evidence has accumulated to indicate that the transport of energy of 1 micron laser light is considerably reduced below that which would be predicted by classical thermal transport.[1] The mechanism for this inhibition is not yet fully resolved. In a separate paper the role of magnetic fields will be discussed.[2] One difficulty in isolating the mechanism is the difficulty in obtaining well-diagnosed experiments that can pinpoint the mechanism. One possible solution is the detailed comparison of experimental plasma profiles with hydrodynamic simulations including various transport models. The development of the x-ray spot spectroscopy technique at NRL has made such comparison of density and temperature profiles into the overdense region possible.[3]

Experimental considerations dictate a minimum laser energy for these transport experiments. At lower energies, smaller focal spot diameters are required to achieve intensities of interest. The effects of inhibited transport are then diminished by two-dimensional plasma expansion. In addition, increased experimental difficulties are encountered due to target surface distortions which occlude diagnostic view of the overdense region and due to the need for increased spatial resolution to diagnose the shorter scalelengths.

We present the results of one and two-dimensional hydrodynamic simulations with laser intensities $\leqslant 10^{14}$ W/cm^2 and spot sizes of up to a millimeter with a 3ns FWHM laser pulse of 1 micron light. The results show that fluxes approach the classical free stream limit in the absense of any flux limitation. At sufficiently large spot sizes, density and temperature profiles are sensitive to the assumed flux limitation. Changes by factors of up to two in peak temperature result from using an ad-hoc flux limitaton of $f = .03$ times the free stream limit. These signatures should be readily detectable in the experimental results.

Work supported by the U.S. Department of Energy

1. W.L. Kruer, Comm. Plasma Phys. and Cont. Fusion 5, 69 (1979)

2. M.H. Emery et. al. in this proccedings

3. P.G. Burkhalter et. al. Phys. Fluids 26(12), 3650 (1983)

SESSION H

Plasma Diagnostics (oral)

Wednesday, May 9
6:30 p.m.—7:45 p.m.

Chairman: E. Fabre (Ecole Polytechnique)

Abstract for the 14th Anomalous Absorption Conference

X RAY SHADOWGRAPHY AND REFRACTOMETRY OF LASER PRODUCED

R. BENATTAR and J. GODART

We present results of experiments which consist to illuminate laser created plasmas with soft X ray radiation (10 Å) coming from an auxiliary plasma created on copper. We use a technique of source point working without any imaging system, the spatial resolution being given by the size of the point source :

first we measure refraction angles of several milliradians through polyethylene plasma created on planar target ;

secondly we show, in X ray shadowgraphy experiments, how to improve spatial resolution.

Images of plasmas created on CH microballoons show two dimentional effects taking place on the edges of the focal spots.

These effects are well described by 2D simulation done by P.C. Roberts and P.D. Thomson of Aldermaston (U.K.).

(oral)

THE CHARACTERISATION OF THE PLASMA CORONA PRODUCED BY SHORT PULSE 1μm RADIATION USING A LINE FOCUS OF < 10^{15} Wcm^{-2}.

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

Department of Engineering Physics
Research School of Physical Sciences
Canberra, A.C.T. 2601.

Recent unsuccessful attempts at generating soft X-ray lasers have led to a questioning of our knowledge of the plasmas produced by line focussed radiation. An f/3.7 cylindrical lens, supplied by the University of Rochester, was used to focus the single beam 20ps ANU Nd: glass laser into a fully characterised focal spot of dimensions ~ 600μm x 10μm. The plasmas produced by irradiating a wide variety of targets including 10μm diameter carbon fibres, larger glass fibres, 1000Å thick carbon films and more massive Al discs were investigated using a number of diagnostics. Conventional and holographic interferometry measured the density, polarimetry checked for the presence of any magnetic fields, a seven channel p-i-n diode array provided temperatures, an X-ray microscope gave soft X-ray images and 2ω measurements gave details of the doppler shift. In addition, a box calorimeter, in a separate series of experiments, gave total absorption measurements. Most of the targets used showed the presence of striations in the density. Although the polarograms showed regions of light and dark fringes, simultaneous checks with opposing angles revealed no detectable differences in structure, indicating the source of depolarization to probably be refraction caused by the density striations. The talk will present further details of the measurements together with computer simulations of line focussed laser plasma interactions.

† Permanent address: L.L.E., University of Rochester.

HIGH SPATIAL RESOLUTION (2D) X RAY DIAGNOSTICS OF THE THERMAL TRANSPORT REGION IN LASER IRRADIATED PLANE TARGET AT 0.53 AND 0.26 μm

P. Alaterre, C. Popovics
Laboratoire de Physiqu des Milieux Ionisés,
Ecole Polytechnique, F 91128 Palaiseau Cédex, France

P. Audebert, J. P. Geindre, J. C. Gauthier
Institut d'Electronique Fondamentale,
Université Paris XI, F 91405 Orsay Cédex, France

Using planar carbon targets with embedded Al tracer dots and X ray spectroscopy we have measured the density and temperature profiles in the thermal transport region with 2D spatial resolution.

The resolution along the laser axis is obtained by our knife edge imaging technique and computer deconvolution. The tracer dots are made small enough to be homogeneous along the line of sight eliminating Abel integration. Radial profiles are obtained by varying the dot position in the focal plane of the lens. The time integration of the relevant emission is limited by using a dot thiner than the ablation depth.

The electronic density is deduced from Stark-profiles of lines in the H and He like Rydberg series.

Our 1D lagrangian fluid code FILM with time dependent ionization is used to show that temperature can be deduced from the ratio of He like to H like Rydberg series emissivities.

Basic experimental results are the following:

I. At 0.53 μm and 0.27 μm laser wavelength the emission is peaked at about 500 eV for the He like series and at about 800 eV for the H like series whatever the laser frequency and irradaince - ($10^{13} < W(w/cm^2) < 3.10^{14}$.

II. The electron density at the spatial position of the maximum of the X ray emission is increasing with the irradiance and at shorter wavelengths. The 1D code predictions are in good agreement with these results, which are comforted by the study of K-shell dielectronic satellite lines.

III. Effect of time integration in density and temperature profiles are investigated with the code. Our experimental results are discussed using two thermal transport assumptions : classical Spitzer conductivity with low free streaming limit, or a nonlocal transport algorithm.

Determination of the Z-Dependence of Plasma Expansion Velocities from Disk Targets using Holographic Interferometry

R. R. Johnson, C. L. Shepard and Gar. E. Busch
KMS Fusion, Inc., Ann Arbor, Michigan 48106

Abstract for Anomalous Absorption Conference
Charlottesville, Va.
May 6-11, 1984
(due March 16, 1984)

Pulsed interferometry has been used extensively to study electron distributions in the subcritical regions of expanding laser-produced plasmas. By using a 20 ps, 0.26 μm laser as the holographic probe source we have been able to study the early-time evolution of the plasma from disk targets. The experiments were performed using aluminum, selenium, and gold targets. Over a sequence of target shots it was possible to determine the expansion velocity as a function of the laser intensity. Using an isothermal rarefaction model, the electron temperature was determined as a function of target material and laser intensity.

The experiments were done under a variety of focusing conditions using f/0.83, f/1.8 or f/5 illumination optics. In some cases, the focal spot at the target was smaller than the diameter of the target. The interferograms for these target shots were Abel-inverted and two-dimensional electron density distributions obtained. This allowed a determination of the velocity transverse to the laser beam which was compared to the planar expansion velocity. Analytic modeling of these experiments will be discussed.

THOMSON SCATTERING BY THE ELECTRON PLASMA WAVE EXCITED BY TWO LASER BEAMS*

Behrouz Amini and Francis F. Chen
University of California, Los Angeles

Excitation of electron plasma waves has been achieved by optical mixing in a well diagnosed theta-pinch plasma. Two counterpropagating CO_2 laser beams are used to excite the electron plasma wave, and a third beam, from a ruby laser, is used to detect the excited wave by Thomson scattering. In the absence of the pump beams, a non-thermal level of plasma oscillations is seen in the Thomson scattered light; the Bohm-Gross frequency is therefore measured directly. When the pump beams are turned on, this peak in the scattered light is enhanced by orders of magnitude, but only if the Bohm-Gross frequency matches the difference frequency between the two pumps. The density resonance is thus confirmed in a self-calibrating way.

* Supported by NSF Grant ECS-83- 0972 and Lawrence Livermore National Laboratory order number 3446905.

SESSION I

Wave-Particle Interactions (poster)

Wednesday, May 9
8:00 p.m.—10:00 p.m.

SOLITON COLLAPSE DURING IONOSPHERIC HEATING

J. P. Sheerin, D. R. Nicholson, G. L. Payne, and L. M. Duncan*

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Analytical and numerical work indicate that during ionospheric heating with high-powered HF radio waves, the oscillating two-stream instability may dominate the parametric decay instability.[1] The oscillating two-stream instability leads to the formation of a set of collapsing, collisionally damped solitons.[2,3] The collapsing solitons may be detected using incoherent scatter radar.[4] Using the heater and radar facilities at Arecibo Observatory, we have investigated this phenomenon experimentally.[5] Recent results from theoretical and experimental investigations will be reported.

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[1] D. R. Nicholson, G. L. Payne, R. M. Downie and J. P. Sheerin, Phys. Rev. Lett. (submitted).
[2] J. C. Weatherall, J. P. Sheerin, D. R. Nicholson, G. L. Payne, M. V. Goldman, and P. J. Hansen, J. Geophys. Res. 87, 823 (1982).
[3] J. P. Sheerin, J. C. Weatherall, D. R. Nicholson, G. L. Payne, M. V. Goldman, and P. J. Hansen, J. Atmos. Terr. Phys. 44, 1043 (1982).
[4] J. P. Sheerin and D. R. Nicholson, Phys. Lett. 97A, 395 (1983).
[5] L. M. Duncan and J. P. Sheerin, Geophys. Res. Lett. (submitted).

ELECTRON HEATING DUE TO PARAMETRIC INSTABILITIES NEAR THE CRITICAL SURFACE AND COLLISIONAL EFFECTS

K. Mizuno, J. S. DeGroot, J. H. Rogers, Wee Woo and P. W. Rambo
Department of Applied Science
University of California at Davis
and
K. Estabrook
Lawrence Livermore National Laboratory

We have extensively studied electron heating due to parametric instabilities in inhomogeneous plasmas. The plasmas are driven by primarily s-polarized microwaves (TE_{10} mode) and primarily p-polarized microwaves (TM_{01} mode). Microwave frequency is $\omega_o/2\pi = 1.2$ GHz (the critical density $n_c = 1.8 \times 10^{10}$ cm^{-3}), and the electron temperature is in the range of $1 \lesssim T \lesssim 3$ eV in both of the devices.

(a) S-polarized microwaves. Strong parametric instabilities are excited near the critical surface even in the self-consistently steepened plasma[1]. The electrons are strongly heated perpendicular to the density gradient. The results agree with the approximate theory: $T_H/T_e \approx A \times 10^{-4} [f_H I\lambda^2/T_e^{3/2}]^{1/3}$, where $A \simeq 1.4$ for $T_e/T_i = 1$ and $A = 1.0$ for $T_e/T_i >> 1$, and I[W/cm^2], λ[μm], and T_e[keV]. Those results also agree with ZOHAR, 2-D (EM) simulation results for laser parameters.

(b) P-polarized microwaves. Resonance absorption is observed near the critical surface[2]. Parametric instabilities are observed on the underdense region $0.6n_c < n < n_c$. Electrons are strongly heated (both hot electrons and thermal electrons) in the long scale length plasma. The hot electron temperature increases with the shelf length. The results approximately agree with 1-D computer simulation results (where heated electrons are cooled to simulate a finite length system).

We have studied the effect of collisions on electron heating. Initial results indicate that thermal heating increases and hot electron production decreases with increasing collisionality[3].

1. K. G. Estabrook and W. L. Kruer, Phys. Fluids 26, 1889 (1983); K. Mizuno, J. S. DeGroot, and K. G. Estabrook, Phys. Rev. Lett. 52, 271 (1984).

2. K. Mizuno, J. S. DeGroot, and F. Kehl, Phys. Rev. Lett. 49, 1004 (1982).

3. J. Denevit, Phys. Fluids 19, 972 (1976).

TRANSITION FROM WAVE BREAKING TO THERMAL CONVECTION IN RESONANCE ABSORPTION

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With a 1-D capacitor particle code /1/, and numerical resolution of the equation for the evolution of the electrostatic field, we have emphasized the transition from wave breaking to thermal convection, in the case of fixed ions. Scale length and temperature effects are put in evidence. Suprathermal electron production occurs in both wave breaking regime and weakly convective regime. Our results are in good agreement with recent analytical solutions /2/ /3/. Wave density pictures clearly show the differences in the propagation of plasma wave in both regimes. Finally we present detailed results on energy balance, and in particular on suprathermal and thermal heating.

/1/. F. HERMELINE Internal Report
/2/. W.L. KRUER Phys. Fluids 22, p. IIII (1979)
/3/. B. BEZZERIDES, S.J. GITOMER Phys. Fluids 26, p. 1359 (1983)

14th Annual Anomalous Absorption Conference

HOT ELECTRON COUPLING AND TRANSPORT IN 10.6 μm LASER TARGET INTERACTION

N.H. Burnett and G.D. Enright

National Research Council of Canada
Ottawa, Ontario, Canada
K1A 0R6

Abstract:

Temporally and spatially resolved layered target fluorescent yield measurements have been used to infer the nature of hot electron target coupling in high intensity (3 x 10^{14} W/cm^2) CO_2 laser-target irradiation. Hot electron energy deposition in the focal vicinity is shown to peak early in the laser pulse with both the hot electron energy flux and apparent hot electron temperature falling sharply near the peak of the incident laser pulse. The duration of the local hot electron flux is observed to be 350 ps compared to the laser pulse FWHM of 750 ps. The target depth dependence of K_α yield and direct observations of target ionization at various depths using shifted K components are indicative of a local hot electron flux peaking at about 3 x 10^{13} W/cm^2 with axial transport characteristic of collisional deposition from two approximately equal components at temperatures of about 10 and 20 keV.

14th Annual Anomalous Absorption Conference

Energetic Electron Distribution in CO_2 Laser-Produced Plasmas

G.D. Enright and N.H. Burnett

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K1A 0R6

At incident intensities of ~2 x 10^{14} W/cm^2 most of the absorbed energy can be accounted for in a hot electron component with a temperature of 15-20 keV. Recently we have confirmed the existence of very energetic electrons with a "temperature" in excess of 100 keV. Careful analysis of the x-ray emission spectrum in the range 100-300 keV has indicated that the electron distribution is non Maxwellian. The fraction of absorbed energy that is accounted for in these very energetic electrons is less than 0.1 percent but it increases very strongly with laser intensity. It is estimated that at intensities $\gtrsim 10^{16}$ W/cm^2 this component will dominate the energy balance. Experiments on layered target x-ray yields have provided further evidence for the non-Maxwellian nature of the electron distribution. The high energy tail of the electron distribution becomes progressively "hotter" at higher electron energy. The distribution of electrons with energy above 400 keV can be best described by a "temperature of ~450 keV.

ONE AND TWO DIMENSIONAL SIMULATIONS ON BEAT WAVE ACCELERATION

W. B. Mori, C. Joshi, and J. M. Dawson
University of California, Los Angeles

D. W. Forslund and J. M. Kindel
Los Alamos National Laboratory

One dimensional simulations on a 2½-D relativistic electromagnetic particle code, in which only a few cells were used in one direction, on colinear optical mixing will be presented. In these simulations the laser rise time, laser intensity, plasma density, plasma temperature and system size were varied. The simulations indicate that the theory of Rosenbluth and Liu is applicable over a wide range of parameters. In addition, simulations with a D.C. magnetic field will be presented in order to study the "Surfatron" concept.

Two dimensional simulations on a 2½-D relativistic electromagnetic particle code were also carried out. In these simulations laser beams for which the beam cross section was finite or infinite were both conducted. The simulations for a finite laser beam indicate that the amplitude of the electric field down the axis of the system is comparable to the electric fields observed in the one-dimensional simulations. Furthermore, as the electrons are accelerated they create an azimuthal magnetic field which confines them along the axis. As a result, the energy gain of the electrons is also comparable to that in the one-dimensional simulations. In addition, the simulations show that the laser beams can both self-focus and filament. The self-focusing results from both relativistic and ponderomotive effects. The mobile ion simulation gave similar results in regards to the longitudinal electric field strength and the maximum energy electrons.

Work supported by: DOE DE-AS08-83DP-40190, NSF ECS-83-10972, LLNL University Support Program

Energy, Space and Time Distribution of Suprathermal X-rays*

C. L. Wang, E. M. Campbell, R. P. Drake,
K. G. Estabrook, G. R. Leipelt and R. E. Turner

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ABSTRACT

The energy, space and time distribution of suprathermal x-rays emitted from laser-plasma interaction were measured at the 0.53 μm Novette and 1.06 μm Shiva laser facilities. The targets included Au, Ni, Cu, Zn, Fe, Pd and Ta disks. The laser intensity, energy and pulse length ranged from 10^{14} to 10^{17} W/cm^2, 0.5 to 4 kJ and 0.6 to 5 ns respectively. A filter-fluorescer spectrometer and filter - NaI (Tℓ) detectors were used to measure the spectra from 6 to 350 keV. A microchannel plate pinhole camera was used to obtain two dimensional images from 20 to 100 keV, and filtered microchannel plates were used for time-resolved measurements. The data are compared with one and two dimensional hydrodynamic (LASNEX) simulations.

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

TAPERED BEAT WAVE ACCELERATOR*

A. Bruce Langdon and Bruce I. Cohen

Lawrence Livermore National Laboratory

Abstract

An attempt to improve the efficiency of acceleration of electrons, from a cool plasma to relativistic energies, is evaluated using theoretical estimates and kinetic simulations.

*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.

THERMAL TRANSPORT IN DENSE PLASMA

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ABSTRACT

In laser generated plasmas, a heat front is formed with increasing density and decreasing temperature. Unavoidably the plasma parameter ($g = 1/n_0\lambda_D^3$) becomes larger, reaching values greater than one. A classical theory of the thermal transport (Spitzer-Harm) is not valid in this region; similarly the Fokker-Planck model is not correct either.

Thermal transport in this region is important for hydrodynamic stability, level of preheating and smoothing of an ablation front.

Simple calculations of the modified thermal transport, based on the Landau-Placzek method, are presented. A local Maxwellian distribution function is assumed in this model. It is shown, however, that the heat transport, dominated by the hydrodynamic fluctuations, is nonlocal and scales differently with temperature and density - $\mathcal{K} \sim (n_e T_e)^{1/2}$ as compared to S-H theory, $\mathcal{K}^{SH} \sim T_e^{5/2}$

SESSION J

Transport and B-Fields (oral)

Thursday, May 10
8:30 a.m.—12:15 p.m.

Chairman: D. Colombant (NRL)

14th Annual Anomalous Absorption Conference
Charlottesville, Virginia
May 6-11, 1984

LOCALIZED HEAT FLOW INSTABILITIES IN LASER PLASMAS

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Abstract

Electromagnetic instabilities driven by large heat flows may amplify temperature non-uniformities and generate strong magnetic fields in laser plasmas. These fields, produced by self-pinching of the ingoing hot electron current and the cold return current, may have a significant impact on heat transport, both radial and lateral. Previous investigations of these instabilities have found temporal growth rates for modes which are uniform in the direction of heat flow. In reality, however, the unstable region is localized between the critical and ablation surfaces. To estimate how much a temperature perturbation imposed at the critical surface will be amplified over this region, and the resulting magnetic fields, we calculate the spatial growth rates for time-independent modes. We also investigate the possibility of absolutely growing modes in the ablating plasma.

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 Lase Energetics.

IRRADIATION OF GLASS MICROBALLOONS AT 0.26 μm

E. FABRE, C. LABAUNE, A. MICHARD, F. BRIAND
(PMI Palaiseau)
J. BRIAND (CPAT Toulouse)

Glass microballons have been irradiated at 0.26 μm with two beams focussed by a f/1 optics with intensity varying from 5.10^{13} to 5.10^{14} W/cm^2. We have analysed different geometries of illumination with the focus in front or behind the target. Pinhole photographs show that the focussing conditions behind the target favour energy deposition on the pole, but also maintain the inhomogeneity of the beam onto the target, and consequently induce strong non-uniformities in the accelerated matter and the imploded core. However, for the focussing in front of the target, it appears that some optical smoothing is attained. The oblique incidence of the beam and refraction effect are responsible for this. This effect is discussed and it seems that for short wavelengths, obliquely incident light will be, while efficiently absorbed, smoothed optically. A second result of this experiment is discussed concerning the ablation in spherical geometry. Preliminary results are compared with other laboratories showing a higher ablation rate at 0.26 μm that at 1.06 μm.

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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.

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 Lase Energetics.

Self-Generated Magnetic Fields and Electron Transport

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In laser-driven fusion, uniform implosion is one of the key issues for successful performance. Among the sources of nonuniformity, an irradiation asymmetry has been believed to be smoothed out by electron thermal conduction. But the inclusion of the self-generated magnetic field may change the situation. The most important point in considering the magnetic field effect is not where the magnetic field is generated, but where the magnetic field exists. In this paper, we discuss the thermal force effect on the magnetic field transport and amplification, and show that the magnetic fields are transported to overdense region with electron heat flux and growing to some magnitude, which is decided by the balance between the convective growing and the collisional diffusion. The Nernst effect proves to be exaclty the same as the convective amplification of the magnetic field in hot electron transport as previously discussed by one of the authors [1].

Associated with the equation governing the magnetic field growth, the thermal force term can be written as

$$\frac{\partial B}{\partial t} = --- + \nabla \times \beta' \nabla T_e + \nabla\left[\frac{\tau_e}{m_e}\frac{\beta_1'' x^2 + \beta_0''}{\Delta}\nabla T_e \cdot B\right] + \nabla \cdot \frac{c^2 \alpha_\perp}{4\pi n_e^2 e^2}\nabla B + \nabla \frac{c^2 \alpha_\wedge}{8\pi n_e^2 e^2 B} B^2$$

in the two-dimensional Cartesian coordinate. Here, all notations are the same as those given in Braginskii's text book. The first term leads to the filamentation of magnetic field by electron cyclotron motion. The second term can be rewritten as $-\nabla v_T B$, where $v_T = \tau_e(\beta_1'' x^2 + \beta_0'')/(m_e\Delta)\nabla T_e$. This term correspond to the convection of magnetic field with the velocity v_T. The third term expresses the magnetic field diffusion by electron-ion collision. The last term denotes the correction to magnetic field pressure. But in our case this last term is negligibly small. Among these effects, the second term, which is called as Nernst effect, is the most interesting one. The velocity v_T is similar to the propagation velocity of heat wave. Since the velocity v_T is larger than the fluid velocity at lower density, the convection velocity $u_i + v_T$ of the magnetic field is directed towards the overdense side near the critical point and towards the underdense side near the ablation front. Hence, the magnetic fields are convected from both sides, underdense and overdense sides, towards the point which satisfies $u_i + v_T = 0$. Our calculation shows that the magnetic fields applied at the critical point is convected inwardly and amplified by 10-100 times for laser intensity of 10^{13}-10^{15} W/cm^2.

The simulation was repeated by changing the material, the laser wavelength, and its intensity. The amplification depends only on the laser intensity, but not on the wavelength or the material. These calculations were also carried out in two-dimension. The results are modified by the pinching effect in the first term in the above equation.

[1] T.Yabe, K.Mima, T.Sugiyama, and K.Yochikawa
Phys.Rev.Lett.48(1982)242.

THERMAL FLUX NHIBITION DUE TO MAGNETIC FIELDS

Mark H. Emery and John H. Gardner
Laboratory for Computational Physics
Naval Research Laboratory
Washington, D.C.

Of critical concern in directly-driven laser fusion systems is the understanding of electron thermal transport between the region where laser light is absorbed and the ablation layer. Evidence has accumulated over the past several years which indicates that the heat flow rate may be strongly inhibited for 1 μm laser light.[1] Computer hydrodynamics models used to interpret experimental results have typically employed, in an ad-hoc fashion, strong flux-limited diffusion which has led to fairly widespread acceptance of a flux inhibition value of $f = 0.03$.

Here we show that the observed flux inhibition can stem directly from the strong magnetic fields generated at the ablation layer as a result of laser asymmetries. With one notable exception,[2] where little, if any, flux inhibition was observed, modest laser asymmetries, 0 (2:1), have been inherent in nearly all flux inhibition experiments. We have incorporated, self-consistently, the generation of magnetic fields and their subsequent influence on the thermal transport into our two-dimensional Eulerian computer model - FAST2D.

We model the interaction of moderate to high intensity (10^{13} W/cm^2 $\leq$ I $\leq$ 10^{15} W/cm^2), short pulse ($\leq$ 1ns) 1 μm laser light on massive (50 mg/cm^2) planar targets. Multimegagauss magnetic fields are generated at the ablation layer as a result of modest asymmetries on the interior of the laser beam profile. These fields are shed from the ablation layer and fill the overdense region which strongly influences the thermal transport. The self-consistent treatment of thermal transport in this environment shows strong thermal flux inhibition which is manifested by the following observations: (1) reduced ablation pressures, (2) reduced implosion velocities, (3) reduced mass ablation rates, (4) density profile flattening and (5) reduced classical absorption; all of which have been experimentally observed. The mass ablation rates obtained from the self-consistent two-dimensional model agree well with a one-dimensional model with an imposed flux inhibition factor of 0.03.

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

1. W.L. Kruer, Comm. Plasma Phys. and Cont. Fusion 5, 69 (1979).

2. B. Yaakobi et al., LLE Report 136 (1982).

QUANTITATIVE SPACE AND TIME RESOLVED MEASUREMENTS OF THE MAGNETIC FIELD PRODUCED BY HIGH INTENSITY 1 μm LASER RADIATION

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Department of Engineering Physics
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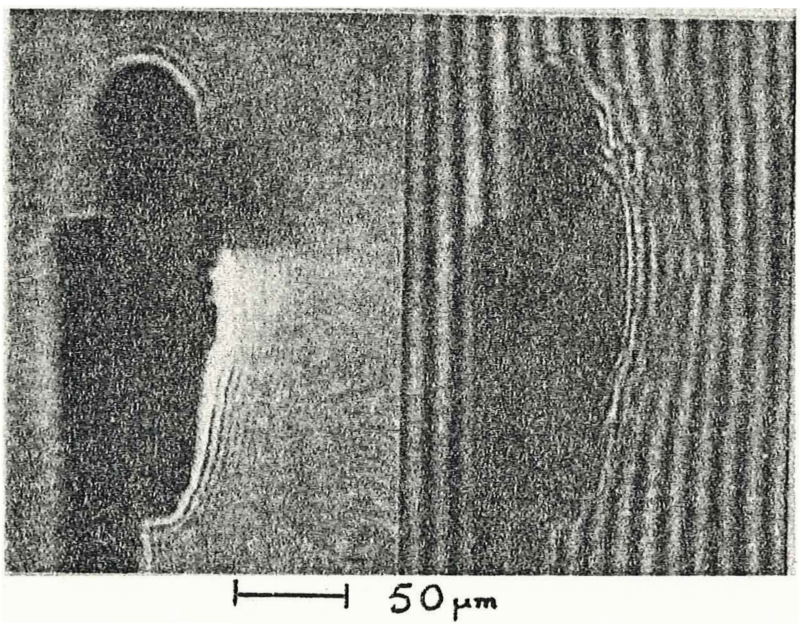
Canberra, A.C.T. 2601.

This talk will present detailed space and time resolved evidence for believing that at high laser intensities a hot electron driven return current loop may be primarily responsible for the generation of ~ 2 MG toroidal magnetic fields. An example of the simultaneous polarograms and interferograms recorded on each shot, using a Wollaston prism set



Simultaneous polarogram and interogram using 0.63μm (Raman shifted) probe beam (< 20ps) of the plasma and its magnetic field at the peak of 20ps, 1μm laser pulse; $I > 10^{17}$ Wcm^{-2}.

between partially crossed polarisers, is shown above. Note in particular both the radial and axial extent of the Faraday rotation, with the characteristic light and dark contrast becoming less visible only as the background plasma density itself falls away; the magnetic field remaining high on axis to the boundary of detectability. The plasmas are generated by a single beam of the Nd: glass laser at the A.N.U. which uses a very tight focus (2μm diameter, in vacuum) to generate the high intensities ($I\lambda^2 > 10^{17}$ Wcm^{-2} μm^2).

DELOCALIZED ELECTRON TRANSPORT IN HOMOGENEOUS MAGNETIC FIELD

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We have shown that in a steep temperature gradient, the electron thermal transport is correctly described by a nonlocal formula

$$q(x) = \int dx' \, q_{SH}(x') \, w(x,x')$$

where q_{SH} is the linear Spitzer-Härm heat flux and w a delocalization function of characteristic width λ[(1)]. We now study related effects which could further reduce the heat flux. In particular a magnetic field perpendicular to the temperature gradient reduces the linear heat conductivity (Braginskii), the delocalization length λ, and the maximum heat flux due to a temperature jump.

(1) J.F. Luciani, P. Mora, J. Virmont, Phys. Rev. Lett. 51, 1664 (1983); J.F. Luciani, P. Mora, R. Pellat, submitted for publication at the Physics of Fluids.

MAGNETICALLY ENHANCED LATERAL TRANSPORT IN CYLINDRICAL GEOMETRY

J. M. Wallace, D. W. Forslund, and J. U. Brackbill
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Los Alamos National Laboratory
Los Alamos, NM 87545

Lateral transport of superthermal electrons in a disk illuminated axially by a focused laser beam is modeled with the VENUS code in cylindrical geometry. The calculation models laboratory target geometries more closely than earlier Cartesian calculations with VENUS. They have a more realistic laser spot to target area ratio and generate magnetized sheaths whose intensity decreases with distance from the laser spot. The effect of these differences on lateral superthermal electron transport, energy flow in the target, and fast ion emission is investigated.

abstract for the 14th annual anomalous absorption conference

THE DYNAMO EFFECT IN LASER PRODUCED PLASMAS

J.BRIAND,V.ADRIAN,M.EL TAMER,A.GOMES,Y.QUEMENER,J.C.KIEFFER,
and J.P.DINGUIRARD

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The importance of the dynamo effect in laser created plasmas is discussed. In particular we show that such an effect can generate toroidal and,or,axial megagauss magnetic fields. Theoretical results are presented on the dynamo effect and on axial fields. The scaling of these fields with the laser wavelength and the incident intensity will be discussed. Furthermore experimental results obtained at various wavelengths demonstrate the presence of large axial fields in laser produced plasmas.

SCALING OF ELECTRON RANGE REDUCTION BY MAGNETIC INSULATION

K. Lee (Los Alamos National Laboratory, Los Alamos NM 87545 USA)

Target preheat by energetic electrons is a key element which significantly degrades target performance. This problem is particularly acute for ICF using a CO_2 laser as a driver. Shielding these energetic electrons by high Z materials causes an unacceptable mass penalty. Vacuum insulation as a means of shielding is only effective until the vacuum is closed off due to the fast-ion expansion driven by the energetic electrons. Here we propose magnetic insulation in the high density plasma as an effective means of reducing the energetic electron range where the magnetic field is imposed in the unionized material. For the magnetic field to be effective, $\Omega_{ce} > \nu_{ei} \propto n_i Z^2/V_H^3$. This condition implies that the magnetic field is very effective in modifying the transport of energetic electrons without impeding the conduction of thermal electrons. For a strong magnetic field the electron range scales as the Larmor radius times the square root of the number of scattering by the ions during its thermalization time, i.e., $V_H(Z)^{0.5}/\Omega_{ce}$ This scaling has been verified by Monte Carlo transport calculations. Enhanced transport due to a collective effect such as drift waves is unlikely since the electron thermalization time is short compared to the ion time scale. However, enhanced transport due to high frequency electron modes remains a possibility. The design of a disk experiment to verify electron range shortening will be presented. If we neglect collective effects, our calculations suggest that a 2.5 Tesla field will reduce the transmitted energy of 100 keV electrons through 1.6 mm CH at 3% of solid density by a factor of 10.

EFFECTS OF MAGNETIC FIELDS ON IF DRIVER REQUIREMENTS

R. D. Jones and W. C. Mead

Los Alamos National Laboratory

Magnetic fields can affect DT fuel in two significant ways, energy losses from electron heat conduction can be greatly reduced as a result of the smaller electron mobility in a magnetic field, and the alpha particles can be forced to deposit their energy locally. Simple zero dimensional calculations[1] indicate the restrictions on drivers can be greatly reduced by the former effect (the latter effect was considered in only a simple way[2]). Simple scaling laws will be presented that indicate there is a magnetic window between 10 and 100 MG in the compressed fuel in which thermal conduction is greatly reduced, alpha particles can be deposited locally, the magnetic back pressure is negligible, and there is significant time for burn to occur. The ignition conditions, along with their effect on target gain, will be discussed. A number of possible heat transport mechanisms, classical and anomalous, will also be presented.

1. I. R. Lindemuth and R. C. Kirkpatrick, Nucl. Fusion 23 263 (1983)

2. R. C. Kirkpatrick and I. R. Lindemuth, Bull. Am. Phys. Soc. 28 1223 (1983)

14th Annual Anomalous Absorption Conference

Magnetic Bubble Formation Produced by an Expanding Laser Plasma*

S.T. Kacenjar, B.H. Ripin, J.A. Stamper, and E.A. McLean

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The expansion of a laser-generated plasma into a low density photoionized magnetized background plasma has been observed to form an expanding magnetic bubble.[1] Sufficient field compression may result in the enhancement of momentum coupling from the target plasma to the ambient plasma by way of various collective plasma processes.

We report on a recent investigation where the ambient pressure of a nitrogen background gas is systematically varied from 10^{-4} torr up to 5 Torr to examine the evolution of the magnetic bubble. Planar aluminum foil targets were irradiated using the Pharos II laser at NRL, with energies from 20 to 50 joules. During this study an externally applied magnetic field of 800 gauss was applied perpendicular to expanding plasma.

Our studies indicate that the magnetic shell becomes less defined as the ambient pressure increases. It is observed that the magnetic field compression rapidly decreases above about 200 mTorr while the shell width becomes less localized.

*Work supported by the Defense Nuclear Agency.

1. "Magnetic Bubble Formation Produced by an Expanding Laser Plasma," S.T. Kacenjar, B.H. Ripin, J.A. Stamper, J. Grun and E.A. McLean, NRL Memorandum Report 5260 (1984).

THEORETICAL FRAMEWORK AND NUMERICAL STUDIES FOR MODELING LASER PLASMA INTERACTION

by

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Los Alamos National Laboratory
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ABSTRACT

We discuss the theoretical framework used to model the interaction of a focused CO_2 laser on a spherical target. In order to model the self-consistent generation of fast electrons, we include the absorption and hot electron spectrum as calculated by WAVE, in a self-consistent fashion, in the multifluid code LASNEX. For numerical studies, the intensity pattern on a target has been chosen to mock-up the experimental pattern.

Because the physics is at least 2D, the effect of self-generated magnetic fields must be taken into account due to the fact that they inhibit the electron transport producing sharper pressure profiles, and hence, fast ions, etc. Detailed comparison between theory and CO_2 experimental data, in which no "fudge" parameters (i.e., flux limitor, etc.) are used, for a given shot is presented.

If time allows, we will discuss similar experiments done with different laser wave lengths (1.0 μm, 0.5 μm, 0.25 μm).

SESSION K

Transport and Hydrodynamics (poster)

Thursday, May 10
7:00 p.m.—10:00 p.m.

ANALYSIS OF PLASMA EXPANSION AND FOIL ACCELERATION DIAGNOSTICS FROM SPECTRAL SHIFT OF LASER LIGHT

E. FABRE, C. LABAUNE, A. MICHARD

In laser irradiated thin foil experiments we have analysed the temporal behaviour of the spectral shift of the laser light, transmitted through the foil, or reflected. The transmitted light presents a red shift when the foil becomes subcritical. A simple analytical calculation permits to explain this red shift and temporal behaviour by the plasma expansion and the time dependance of the phase.

The reflected light itself shows, when the thin foil is still overdense, a red shift which can be explained by the usual Doppler shift coming from the motion of critical layer and the phase variation associated to the mass flow through the critical layer .

Numerical simulation is used to describe the time evolution of the spectrum. The comparison with experiment shows that the major contribution is due to the Doppler shift associated with the motion of the target. Velocity of accelerated matter of the order of $3-5.10^7$ cm/s for very thin foils has been deduced. This technique is very interesting for the analysis of foil acceleration during the laser pulse.

Abstract for the 14th Anomalous Absorption Conference

100 eV IMAGING OF LASER PRODUCED PLASMAS IN THE TEMPERATURE GRADIENT REGION

R. BENATTAR and J. GODART

With a technique using XUV multilayerd mirror, studied and manufactured by J.P. CHEAUVINOT and Institut d'Optique of Orsay University (France), we record images of laser created plasmas in the 155 Å (80 eV) range.

These images exhibit very thin emissive zones very spread in the lateral direction and localized in the vinicity of the target.

For aluminium created plasmas, this bright and thin emission gives the location of lithium-like species, created during the laser pulse in the beginning of the sharp temperature gradient just where the thermal front propagates. The results are in good agreement with computer simulation done with hydrocode FILM working with atomic physics.

These experiments give information on plasma zone in which we begin to undertake measurement of XUV refraction at 155 Å and where anomalous dispersion takes place.

(poster)

PRESSURE SCALING OF SHOCK SPEED IN LASER-IRRADIATED SOLIDS

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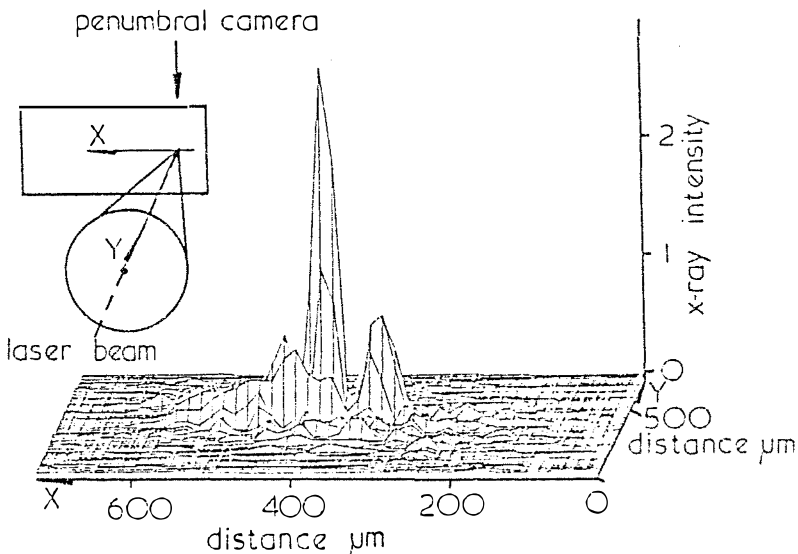
Physics Department, University of British Columbia
Vancouver, British Columbia, Canada, V6T 2A6

The propagation of shock waves in aluminum has been studied by irradiating planar, aluminum targets with 0.53 μm, 2 nsec (FWHM) laser light at intensities of 10^{12}-7×10^{13} W/cm^2. For different irradiances, the shock transit times through targets of various thicknesses were obtained by measuring the on-set of target rear surface luminescence due to the shock break-out. From these, the speed of the laser-generated shock wave was derived. The ablation pressure P_a which drove this shock wave in the solid was obtained independently from ion measurements. In the pressure range of 0.5-13 MBar, the shock speed in aluminum was found to scale as $P_a^{0.4}$. The results are in good agreements with theory and other experiments. Shock speed measurements have also been made in targets of different Z.

PENUMBRAL X-RAY IMAGING MEASUREMENTS OF MAGNETIC FIELD INDUCED SURFACE TRANSPORT USING 1μm LASER IRRADIATED DISC TARGETS

K.A. Nugent, M.D.J. Burgess, B. Luther-Davies
Department of Engineering Physics
Research School of Physical Sciences
Canberra, A.C.T. 2601.

This poster will present a new coded aperture imaging technique which uses a single large circular aperture to image the high energy x-ray emission from our laser produced plasmas. In the method, known as penumbral imaging, the source casts a shadow on the aperture at the film plane. The source distribution can be reconstructed from the penumbral image by deconvolution provided that the source is smaller than the aperture. In the example of one such reconstructed image shown below,



A reconstructed image of the 20 keV X-ray emission from a copper target illuminated as indicated.

the 20 keV X-rays emitted from a copper target irradiated by the single beam ANU Nd:glass laser at an intensity > 10^{17} Wcm^{-2} were used. The narrowness of the focal emitting zone and the sharpness of the enhanced emission remote from the focal region, when the laser pulse duration is only 20ps, strongly indicates the leading role of the self-generated magnetic field (described in more detail elsewhere at this conference) in the transport of incident laser energy at high laser intensities.

Fokker-Planck-Landau simulations of laser-plasma interaction

Alain Decoster

CEA-Limeil, BP27, 94190 Villeneuve-Saint-Georges, France

Absorption and transport of laser energy, when electron distribution functions are not Maxwellian, are described by Fokker-Planck equation for the electrons - with Landau collision terms and Langdon inverse bremsstrahlung absorption term - and fluid equations for the ions. It is possible to make on this set of equations the same one-fluid approximation as made in hydro codes, thus eliminating electric current and field.

This new Fokker-Planck-Landau code describes so the low-frequency evolution of the plasma. Implicit calculation of the collisions allows a description of the collisional plasma inside the target without reducing the timestep. Discretization has been made so as to numerically insure approach to equilibrium, conservation of density, momentum and energy, as well as first-order Galilean invariance, and Onsager reciprocity relations near equilibrium.

Simulations of laser-matter interaction experiments will be presented, with comparisons to flux-limited fluid simulations.

4TH/14

14th ANNUAL ANOMALOUS ABSORPTION CONFERENCE
Charlottesville, Virginia, May 6-11 1984.

Electron Heat Flow with Classical and Resonant Absorption and Hydro Motion

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ABSTRACT

We have shown[1] that modelling laser-target interaction with our Fokker-Planck code, including classical (inverse Bremsstrahlung) absorption and self consistent ion motion, gave high values of the heat flow: 10-15% of the free-streaming limit, with the parameters $\lambda = 1\ \mu$, $I = 3 \times 10^{14}$ W/cm^2, $Z = 4$. We will add a fast electron source, modelling resonant absorption, and show its effect on heat flow. Comparison to the LILAC hydrocode (with various flux limiters f) will also be shown.

[1]: J.P. Matte, T.W. Johnston, J. Delettrez, R.L. McCrory and J. Virmont, Bull. Am. Phys. Soc. 28, 1083 (1983).

LASER BURN-THROUGH IN THIN FOILS

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Thin aluminum foils have been irradiated with 0.53 μm, 2 nsec (FWHM) laser pulses focussed to spot diameters ⩾ 80 μm at target irradiances of 10^{12}-4×10^{13} W/cm^2. Early burn-through of the targets was observed. The spatial and temporal characteristics of the transmitted laser light were studied using a streak camera. The results showed that target burn-through occured almost simultaneously across the entire focal region and the turn-on times of laser-transmission were typically 100 psec. The burn-through process was therefore a whole-beam effect and was thought to result from the rarefaction of the shock compressed target by axial and lateral rarefaction waves. The burn-through time was also compared with the transit time of the laser generated shock wave in the target.

Experimental Data of Electron Transport in Laser-Fusion Targets.

A. H. Bennish, J. Delettrez, G. H. Miley, D. B. Harris, D. R. Welch, and A. Entenberg.

Alpha-particle and proton energy spectra obtained from short-pulse-length target shots on the Omega Laser System have been used to study and modify the parameters used in the hydrodynamics code LILAC. Experiments were performed using thick ($\geq$ 1.75-μm) glass-walled microballoons which were imploded using uniform illumination at 1.06-μm wavelength with a pulse length of about 100 ps. A time-of-flight spectrometer was used to measure the alpha particles and protons. The three parameters which were varied in LILAC correspond to the flux limiter, the suprathermal-electron source temperature, and the fraction of the absorbed energy resulting from inverse Bremsstrahlung. It was found that the LILAC-predicted yields and energy spectra were insensitive to the flux limiter, but were sensitive to the other two parameters. By varying these two parameters, a good fit was obtained to the experimentally measured yield and energy spectra. Previously, these two parameters had been estimated without the use of measured energy spectra. Using these thick-walled microballoons in addition to thin-walled microballoons, better limits on these two parameters associated with the suprathermal-electron transport were obtained. The suprathermal-electron source temperature as obtained from the scaling law(1) should be multiplied by a factor of two and the fraction of the energy absorbed through inverse Bremsstrahlung should be decreased by at least a factor of four. The LILAC simulations run with the new set of parameters predict a more explosive implosion which will be discussed.

1. Kent Estabrook and W. L. Kurer, PRL 40, 42 (1978).

LASER BEAM CLEANING IN A PLASMA CELL

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One of the technical difficulties that will be encountered in laser driven ICF is the generation of laser beams with adequate spatial coherency. The contributing effects of unstable oscillators, many optical components, and the nonlinear lasing and amplifying media result in significant modulations in the beam transverse profiles. The resultant beams are not single-mode and are typically far from being diffraction limited. A number of technical requirements dictate the need for coherent beams. These include the ability to accurately focus the laser beams, the absence of beam hot spots which can otherwise lead to optics damage and the need to ensure beam uniformity on a target, particularly when short wavelength lasers are used. In this paper, we discuss the possibility of cleaning high power laser beams by employing Raman backscattering in a plasma waveguide. In this scheme, an intense incoherent pump beam is propagated in a plasma cell while, at the same time, a more coherent seed Stokes pulse is propagated in the opposite direction. It is shown that the Stokes pulse can be amplified by large factors while still retaining much of its initial coherency. Two cases are considered. In one, the cleaning of a KrF laser pulse takes place in a plasma compressor. In the other, a CW CO_2 laser beam is cleaned in a short (~ 10 cm) plasma cell.

MODEL FOR GAIN VS. LASER ENERGY FOR DIRECT DRIVE TARGETS*

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Abstract

We analytically derive, from first principles, an optimal gain vs. laser energy for viable ICF targets. We first appeal to the model [1] of Meyer-ter-Vehn for the optimal gain, G, of an assembled DT fuel, with internal energy ηE. This model provides expressions for the optimal "rocket-payload" mass, M, and velocity, V, in terms of ηE.

We then cull from analytic models [2, 3] of steady state spherical ablation, numerous relevant quantities subject to achieving the required M and V. In particular, we find the hydro efficiency, η_H, as well as the in-flight-aspect-ratio (IFAR) of the shell. In practice, IFAR is constrained so that the target survives Rayleigh-Taylor instability growth during the implosion.

We proceed to find η_H (for any ηE scale target) as a function of laser wavelength, critical to ablation surface standoff distance, and IFAR. Making reasonable assumptions regarding absorption fractions, we find $\eta = \eta(\eta E)$. Combining this with $G = G(\eta E)$, we obtain $G = G(E)$. Assuming perfect uniformity, η is maximized at short wavelength. Keeping IFAR reasonable (less the 50) leads to a best gain of only 30 at the 3 MJ scale driver.

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

1. J. Meyer-ter-Vehn, Nucl. Fus. 22, 561 (1982)
2. C. E. Max, C. F. McKee, and W. C. Mead, Phys. Fluids 23, 1620 (1980)
3. C. E. Max, J. D. Lindl, and W. C. Mead, Nucl. Fus. 23, 131 (1983)

14th Annual Anomalous Absorption Conference

Under-dense, planar plasma production by low intensity, laser-driven thin-film explosions

F.J. Mayer, Gar. E. Busch and J.A. Tarvin

Low-intensity ($\lesssim 10^{11}$ W/cm^2), short (~ 100 psec.) laser pulses are transmitted through thick glass substrates to thin aluminum coatings. The substrates are either 1 mm or 180 μm thick and the aluminum films are typically ~ 1000 Å. The laser spot diameter was nominally 500 μm. Because the glass substrate is inertially confined, the aluminum layer is exploded in a remarkably planar fashion from the substrate surface. The planar metal film explosion is observed with pulsed shadowgraphy and optical measurements made on the substrates after the event.

A specialized version of self-similar solutions to this planar thin film explosion[1] are described and applied to our experiments. A number of laser-plasma experiments as well as other interesting applications are described.

(1) L.I. Sedov, Similarity and Dimensional Methods in Mechanics, Academic Press, NY, 1959, p. 271.

EXPERIMENTAL INVESTIGATION OF SATELLITES INTENSITIES AND LINE PROFILES IN DENSE PLASMA USING SPOT SPECTROSCOPY AND KNIFE EDGE IMAGING

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The H-like Lyman α line and the He-like $1s3p-1s^2$ line have been observed with there adjacent dielectronic satellites lines in Al and Si targets. The spatial resolution is obtained by using embedded dot on carbon and by our knife edge technique and computer deconvolution.

Electronic density and temperature are measured from stark profiles and relative intensity of lines in Rydberg series. Electronic density is varied by using 1.06, 0.53, 0.27 μm wavelength and different laser irradiances.

Lyman α satellites

The $(1s2p^3P-2p^23P)/(1s2s^3S-1s2p^3P)$ line ratio strongly increases with the electronic density. Numerical simulations including ground, singly excited and doubly-excited levels of configurations $2\ell_a\ 2\ell_b$ and $2\ell_a\ 3\ell_b$ in a collisional radiative equilibrium model including photon pumping effects are in a good agreement with experimental data. Plasma electric field broadening of satellites lines is also exhibited at high electron densities.

Lyman β satellites

The dielectronic satellite lines from $1s2\ell_a3\ell_b$ and $1s3\ell_a3\ell_b$ doubly excited configuration of lithium like ions have also been studied. Good agreement between theory and experiments show that collisional equilibrium conditions are reached between n=3 singly and doubly excited levels at electron densities greater than 10^{22} cm^{-3} in Al and Si.

SESSION L

Hydrodynamics and Rayleigh-Taylor (oral)

Friday, May 11
8:30 a.m.—11:45 a.m.

Chairman: J. Tarvin (KMS)

A KrF LASER FACILITY FOR SHORT WAVELENGTH LASER/MATTER INTERACTION EXPERIMENTS

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ABSTRACT

A first generation KrF laser has been developed for laser/matter interaction experiments. The laser system - comprising discharge excited oscillator, injection-locked regenerative amplifier and 2 pre-amplifiers plus E-beam excited main energy storage amplifier - should be capable of producing a nominal 10J, 2-3 ns pulse with 150 μrad beam divergence and focused intensity on target > 10^{14} watt/cm^2 when fully operational. The 60 ns E-beam excited amplifier now routinely delivers 35J in 20 ns with a triple beam extraction arrangement. Pulse compression utilizes beam multiplexing and stimulated Raman scattering in methane. Features of the system, including Raman and Brillouin pulse compression studies, along with preliminary target irradiation measurements will be reported.

LASNEX MODELING OF THE OSAKA HIGH-Z DISC EXPERIMENTS

by

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ABSTRACT

The LASNEX hydrodynamics code was used to model short-wavelength laser irradiation experimental results recently published by Osaka University.[1] High-Z gold discs irradiated with frequency-doubled and frequency-tripled 1.06 μm laser light with intensities ranging from 10^{12} to 10^{14} watts/cm^2 at τ_L = 500 ps are examined here. For these conditions, inverse bremsstrahlung is the predominant target energy absorption mechanism.

Experimental results modeled include radiation conversion efficiency for thick discs (10 μm) and emission from the rear surface of thin foils (0.2 μm to 2 μm). The Osaka conversion efficiency data shows a monotonic increase in conversion efficiency with increasing laser intensity. This trend is consistent with the lowest intensity previously-published LLNL data[2] where the conversion efficiency was observed to peak at 3×10^{14} w/cm^2. The LLNL high intensity regime ($I > 3 \times 10^{14}$ w/cm^2) required a reduced electron flux limiter. To model the Osaka data, we require "classical" electron transport ($f_e > 0.1$). Our simulations predict a conversion efficiency which is higher than the data. Possible models which fit the measured emission from front and rear target urfaces will be discussed.

References

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2. Mead, *et* al, Physics of Fluids <u>26</u>, 2316 (1983).

SCALING OF HIGH-Z PLASMA PARAMETERS

by

S. R. Goldman, W. C. Mead, B. Bezzerides,
C. W. Cranfill, and R. D. Jones

Los Alamos National Laboratory

We present the results from a number of one-dimensional simulations of gold foils irradiated by 1/4 μm light at an intensity of 3×10^{14} W/cm^2, and variable total energy E, with pulse width varying as $E^{1/3}$. We discuss energetics of the plasma. We consider the scaling of conversion efficiency, mass ablation rate, ablation pressure, coronal temperatures, critical surface motion, density scale length, degree of ionization, and laser coupling processes. Calculations are done with LASNEX in non-LTE; sensitivity to non-LTE rate variations and electron transport will also be explored. Results are compared with theoretical modeling.

Diagnostic of Plasma Corona Dynamics

Yu.A. Zakharenkov

Lebedev Physical Institute, USSR

STUDY OF ABLATIVELY ACCELERATED TARGETS AT λ = 0.26μm

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In experiments realized at λ = 0.26μm, in the intensity range of 10^{13}-10^{15} W/cm^2 and at 0.5 ns pulse duration, we have studied different properties of ablatively accelerated aluminium targets. First we determined the applied ablation pressure using different methods : by measuring the velocity of the accelerated foil with the double-foil technique or by measuring the velocity of the induced shock wave. Typically at 10^{15} W/cm^2, the pressure is 50 Mbar. This pressure induces a shock wave with a velocity of 50 μm/ns in aluminium and accelerates a 27 μm aluminium foil thickness at a velocity of 30 μm/ns. Secondly, we have studied the inhomogeneity of the acceleration of the target. At low laser intensity ($\sim 10^{13}$ W/cm^2) the profile of acceleration of the target is explained by the presence of hot-spots in the focal spot. This velocity modulation increases when the initial foil thickness decreases since the local increase of the mass ablation rate in the hot spots introduces a rise in the local target velocity.

Finally, we measured the rear side temperature in order to study the preheating mechanisms. This rear-side temperature is measured by optical and soft X-ray pyrometry. Two different processes of preheating will be discussed : The shock wave and X-ray heating ; Data on soft X-ray spectra and X-ray conversion efficiencies will be presented.

14th Annual Anomalous Absorption Conference
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May 6-11, 1984

IRRADIATION OF SP ERICAL SHELL TARGETS WITH 6 UV OMEGA BEAMS

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Abstract

The availability of a multi-beam UV irradiation facility permits, for the first time, the study of the performance of spherical targets directly driven under collisional absorption in the absence of preheat and smoothing effects produced by superthermal electrons. Six upconverted (351 nm) beams of OMEGA focused by f/3.5, 60 cms focal length optics oriented in an approximately cubic irradiation geometry have been fully characterized and the level of energy deposition uniformity estimated numerically and experimentally. The reaction of targets to specific levels of irradiation uniformity is under study. The implosion characteristics of a variety of targets under the most uniform irradiation conditions are investigated with a number of diagnostics and are compared with the predictions of one- and two-dimensional hydrodynamic codes.

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 Lase Energetics.

STUDIES OF THE RAYLEIGH-TAYLOR INSTABILITY IN THREE DIMENSIONS*

D. G. Colombant, W. M. Manheimer and E. Ott**

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Plasma Physics Division
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A numerical scheme has been developed to examine the nonlinear evolution of the Rayleigh-Taylor instability of a thin sheet in three dimensions. Although not as complete as other 3D models,[1,2] it is much faster to run and quite a number of different cases have already been run. For the first series of runs, the emphasis has been on comparisons between the instability of a thin layer in 2D and 3D. The main result of these comparisons was that the mass is lost into spikes more slowly in 3D than in 2D. More recently, attempts are being made at simulating experiments in 3D. Preliminary simulation results will be presented for an experiment with $kd < 1$.

1. Y.M. Davydov and M. S. Panteleev, J. Appl. Mech. Tech. Phys. 21, 97 (1982).
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* Work supported by DOE
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Forced Rayleigh-Taylor Instability in Nonuniform Irradiation

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The thermal smoothing of nonuniform irradiation has been investigated, emphasizing the reduction in nonuniformity of ablation pressure through so-called cloudy day effect[1]. On the other hand, the Rayleigh-Taylor(R-T) instability has long history in inertial fusion and its eigen mode analysis is studied self-consistently, resulting the reduction of growth rate compared to $\sqrt{kg}$ [2]. Coupling of nonuniform irradiation with the R-T instability has been demonstrated with 2-D simulation in Ref.3.

In order to relate the velocity perturbation, which is seeded by nonuniform irradiation and grows due to R-T instability, to the irradiation nonuniformity, we investigate linear developement of fluid perturbation in stationary ablating plasma, and find the dependence on the wavenumber and background structure. One-fluid one-temperature fluid equations are used as basic ones in spherical geometry. The time developement of linear perturbations decomposed by the spherical harmonics are studied as an initial value problem with heat flow perturbation at the critical point. The finite difference method is used.

The phenomena seen along time are found to be characterized by the following three steps. 1)Pressure perturbation is formed in the conduction region through temperature perturbation distributed by electron thermal conduction. 2)The pressure perturbation at the ablation front drives velocity perturbation in the conduction region. At the same time, fluid motion is also induced in the conduction region. 3)The velocity perturbation in the compressed region, in which the gravitational potential energy is released dominantly compared to in the ablation region, plays the role of a seed for R-T instability, and the perturbations start growing exponentially with the eigen mode structure.

We found the assymptotic formula to the perturbation of accelerated pusher at time t:

$$\delta V_\ell = 6.0\,(\rho_{cr}/\rho_a)^{1/2} C_{sa} \exp(-\tilde{D}\ell + \gamma_\ell t)\cdot[\delta I_{ab}/\langle I_{ab}\rangle]_\ell$$

where ρ_{cr}/ρ_a is the critical density divided by the density at ablation front, C_{sa} is the sound velocity at ablation front, $\tilde{D}$ is the distance of the conduction region divided by the radius of the critical point, γ_ℓ is the R-T growth rate obtained in Ref.2, and $[\delta I_{ab}/\langle I_{ab}\rangle]_\ell$ is the absorbed power nonuniformity with mode number ℓ.

The stability of the ablative implosion is studied by using the above formula and coupling it with the code for calculation of absorption nonuniformity. In addition, the magnetic field generated by $\nabla n \times \nabla T$ is found to give rise to the feedback effect to fluid motion and modify the above formula even in linear regime.

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2) H. Takabe, K. Mima, L.Montierth, and R. L. Morse (submitted to Phys. Fluid)
3) R. G. Evans, A. J. Bennet, and G. J. Pert, Phys. Rev. Lett. 49, 1639 (1982)

Recent Experimental Results from the Rutherford Laboratory

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Abstract

The six 0.53μm beams from the VULCAN Nd glass laser at the Rutherford Laboratory have been used to drive stable ablative implosions to about 10% of the initial target radius. Thinner walled targets have yielded sufficient DD protons to measure the symmetry of the pusher material at the time of thermonuclear reaction.

The development of Rayleigh Taylor "spikes" has been observed on the outside of mass modulated spherical targets using X-ray backlighting. After correction for differential acceleration the growth rate is measured to be about one half of the classical value.

Related numerical simulations will also be discussed.

GROWTH RATE SCALING IN THE ABLATIVELY DRIVEN RAYLEIGH-TAYLOR INSTABILITY*

Wallace M. Manheimer and Denis G. Colombant

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Two recent works dealing with the linear theory of the Rayleigh-Taylor instability of an ablatively accelerated fluid[1,2] show that the growth rate divided by $\sqrt{kg}$ depends on the single parameter kd where d is the thickness of the accelerated slab. This scaling is tested by comparing it with recent fluid simulations of the ablatively driven Rayleigh-Taylor instability.[3,4,5] It is shown that for all simulations $\gamma/\sqrt{kg}$ as a function of kd lie reasonably near a single, "universal" curve.

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*Work supported by DOE

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Charlottesville, VA, 6-11 May 1984

Measurements of Rayleigh-Taylor Caused Mass Redistribution*

J. Grun, P.G. Burkhalter, D. Colombant, M.H. Emery, S. Kacenjar,
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The Rayleigh-Taylor instability in fusion pellet shells redistributes mass within the shell, thereby degrading implosion symmetry and fuel compression.

Using ablatively accelerated foils (1.05 μm, 10^{13} W/cm^2, 5 nsec FWHM laser) to model these pellet shells, we are making absolute, temporally resolved, and two-dimensionally-resolved measurements of the areal-mass redistribution caused by Rayleigh-Taylor using face-on x-ray backlighting.[1,2] Current data and numerical simulations of our experiment are in agreement.

*Work supported by the U.S. Department of Energy, the Defense Nuclear Agency, and the Office of Naval Research.

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List of Pre-registered Attendees

14th Annual Anomalous Absorption Conference

List of Pre-registered Attendees

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Plenary Session for Next Year's Meeting

Friday, May 11
11:45 a.m.—12:15 a.m.