35th Annual Anomalous Absorption Conference

June 26 - July 1, 2005
Fajardo, Puerto Rico

Organizing Committee
J. Bates M. Karasik J. Weaver
U. S. Naval Research Laboratory
Washington, DC

35^{th} Annual
Anomalous Absorption Conference

Wyndham El Conquistador Resort
Fajardo, Puerto Rico
June 26^{th} – July 1^{st}, 2005

Organizing Committee:

J. Bates, M. Karasik, J. Weaver
U. S. Naval Research Laboratory
Washington, DC

Conference Coordinator:

J. Strauss
Strategic Analysis Inc.
Arlington, VA

35th Annual Anomalous Absorption Conference
Fajardo, Puerto Rico — June 26th - July 1st, 2005

Sunday June 26th

6:00 - 10:00 PM		Registration	
8:00 - 10:00 PM		Welcome Reception	

Monday June 27th

Welcome/ Opening Remarks

8:45 - 9:00 AM		Conference Organizing Committee	

Oral Session: LPI/Parametric Instabilities — Session Chair: A. J. Schmitt

9:00 - 9:20 AM	MO1	B. Afeyan	The Physics of KEEN Waves in Laser Produced Plasmas *B. Afeyan, V. Savchenko, K. Won, T. Johnston, A. Ghizzo, P. Bertrand, J. Kline, Bertche, N. Kumit, D. Montgomery, C. Niemann*
9:20 - 9:40 AM	MO2	J. L. Kline	Thomson Scattering Detection of Pondermotively Driven Kinetic Electrostatic Electron Nonlinear (KEEN) Waves in a Laser Produced Plasma *J. L. Kline, B. B. Afeyan, W. A. Bertsche, R. P. Johnson, N. A. Kurnit, D. S. Montgomery, V. Savchenko, K. Won, C. Niemann*
9:40 - 10:00 AM	MO3	D. S. Montgomery	Evidence of a Nonlinear Dispersion Relation for Langmuir Waves? *D. S. Montgomery, J. L. Kline*
10:00 - 10:20 AM	MO4	H. A. Rose	Bare-Bones Langmuir Wave Model in Kinetic Regime *H. A. Rose*
10:20 - 10:40 AM	MO5	W. Seka	Various Forms of Stimulated Brillouin Scattering in Long-Scale-Length Plasmas Relevant to Direct-Drive Inertial Confinement Fusion *W. Seka, H. Baldis, A. V. Maximov, J. Myatt, R. W. Short, R. S. Craxton, R. E. Bahr, T. C. Sangster*
10:40 - 11:00 AM		Coffee Break	

Oral Session: Ultra-Short Pulse — Session Chair: F. S. Tsung

11:00 - 11:20 AM	MO6	E. Esarey	Electron Acceleration, THz and X-ray Generation in Short-Pulse Laser-Plasma Experiments at LBNL *E. Esarey, C. Filip, C. G. R. Geddes, A. J. Gonsalves, S. Hooker, E. Michel, P. Michel, B. Nagler, K. Nakamura, C. B. Schroeder, C. Toth, J. van Tilborg, W. P. Leemans*
11:20 - 11:40 AM	MO7	R. J. Mason	Target Configuration Influences on Short-Pulse Laser-Matter Interactions *R. J. Mason, E. S. Dodd, A. J. Albright*
11:40 - 12:00 PM	MO8	K. Flippo	Laser-Produced Heavy Ions via Laser-Ablation-Cleaning and Proton Acceleration Suppression *K. Flippo, B. M. Hegelich, M. J. Schmitt, E. Dodd, J. A. Cobble, D. C. Gauthier, R. Gibson, R. Johnson, S. Letzering, J. C. Fernandez, T. Lin, A. Maksimchuk, M. Rever, D. Umstadter*
12:00 - 12:20 PM	MO9	B. M. Hegelich	Material and Temperature Dependence on Species and Spectral Properties of Laser Accelerated Ions *B. M. Hegelich, K. Flippo, B. J. Albright, J. Cobble, C. Gautier, R. Johnson, S. Letzring, M. Paffett, R. Schulze, J. C. Fernandez*
12:20 - 12:40 PM	MO10	E. Esarey	Nonlinear Group Velocity, Pump Depletion, and Electron Dephasing in Short-Pulse Laser-Plasma Interactions *E. Esarey, C. B. Schroeder, B. A. Shadwick, W. P. Leemans*

Evening InvitedTalk

7:30 - 8:30 PM	MI1	J. C. Fernandez	Gas-Filled Hohlraum Experiments at the National Ignition Facility *J. C. Fernandez, S. R. Goldman, J. L. Kline, C. Gautier, G. P. Grim, B. M. Hegelich, D. S. Montgomery, N. Lanier, H. Rose, J. B. Workman, D. Braun, K. Campbell, E. Dewald, S. Glenzer, D. Hinkel, J. Holder, D. Kalantar, J. Kamperschroer, J. Kimbrough, R. Kirkwood, O. Landen, B. MacGowan, A. Mackinnon, J. McDonald, C. Niemann, J. Schein, M. Schneider, L. Suter, B. Young*

Evening Poster Session

8:30 - 11:00 PM

	MP1	H. Rose	Collective FSBS: Influence of High Z Dopant *P. Lushnikov, H. Rose*
	MP2	E. A. Williams	Two-Dimensional Simulations of Stimulated Brillouin Backscattering: Effects of Ion-Ion Collisions and Inhomogeneity *B. I. Cohen, B. Langdon, L. Divol, E. A. Williams*
	MP3	B. J. Winjum	Stimulated Raman Scattering in One Dimension *B. J. Winjum, F. S. Tsung, W. B. Moir, A. B. Langdon*
	MP4	B. J. Winjum	Stimulated Raman Scattering in Two Dimensions and Density Gradients *B. J. Winjum, F. S. Tsung, W. B. Mori*
	MP5	P. Loiseau	Smoothing Induced by Stimulated Brillouin Scattering in an Inhomogeneous Plasma *P. Loiseau, M. Casanova, S. Hüller, O. Morice, D. Pesme, D. Teychenne*
	MP6	U. Feldman	Absolutely Calibrated Spectra in the 150 nm to 250 nm Range from Nike KrF Laser Produced Plasmas *U. Feldman, J. F. Seely, G. E. Holland, J. L. Weaver, C. M. Brown, A. N. Mostovych, S. P. Obenschain, A. J. Schmitt, R. Lehmberg, B. Kjomarattanawanich, C. A. Back*
	MP7	H. Brown	Degenerate Four-Wave Mixing in Vacuum *H. Brown, Q. Yang, J. T. Seo, K. Baker, A. Afanasev, B. Tabibi, S.M. Ma, S. S. Jung, H. Wang*
	MP8	M. Tzoufras	Emergence of Space Charge Effects in the Linear Stage of the Wiebel-Like Current Filamentation Instability *M. Tzoufras, F. S. Tsung, J. W. Tonge, W. B. Mori, C. Ren, L. O. Silva, M. Fiore*
	MP9	B. Afeyan	Wavelets, Curvelets and Multiresolution Analysis Techniques Applied to ICF and Z Pinch Research *B. Afeyan, K. Won, J. L. Starck, M. Cuneo, G. Bennett, R. Stephens, D. Montgomery*
	MP10	A. L. Velikovich	Small-Amplitude Theory of Interaction of Rippled Shock and Rarefaction Waves in Laser-Driven Targets *A. L. Velikovich, N. Metzler*
	MP11	M. Karasik	High Dynamic Range Imprint Measurements on Nike Laser *M. Karasik, Y. Aglitskiy, V. Serlin, J. W. Bates*
	MP12	J. W. Bates	Hydrodynamic Stability of Direct-Drive High-Gain IFE Targets *J. W. Bates, A. J. Schmitt, D. E. Fyfe, J. H. Gardner*
	MP13	M. Klapisch	A New Algorithm for Solving non-LTE Atomic Populations in Hot Plasmas *M. Klapisch, M. Busquet*
	MP14	C. G. Constantin	Stimulated Raman Scattering from Hot Underdense Plasmas *C. G. Constantin, H. A. Baldis, M. B. Schneider, D. E. Hinkel, A. B. Langdon, W. Seka, R. Bahr, S. Depierreux*
	MP15	P. E. Masson-Laborder	Modeling Parametric Scattering Instabilites in Large-Scale Expanding Plasmas *P. E. Masson-Laborde, S. Hüller, F. Detering, D. Pesme, M. Casanova, P. Loiseau, O. Morice*
	MP16	M. Casanova	Revisiting Stimulated Brillouin Scattering in Inhomogeneous Plasmas *M. Casanova, P. Loiseau, O. Morice, D. Teychenne, S. Hüller, D. Pesme*

Tuesday, June 28th

Oral Session: Hydrodynamics			Session Chair: V. N. Goncharov
9:00 - 9:20 AM	TO1	G. Hazak	Distribution of Sizes in the Mixed State Generated by Rayleigh-Taylor Instability *G. Hazak, Y. Elbaz, J. H. Gardner, A. L. Velikovich, A. J. Schmitt*
9:20 - 9:40 AM	TO2	H. Azechi	Critical Path to Impact Fusion Ignition - Suppression of Rayleigh-Taylor Instability *H. Azechi, M. Murakami, H. Nagatomo, T. Sakaiya, S. Fujioka, H. Shiraga, M. Nakai, K. Shigemori, A. Sunahara, S. Obenschain, M. Karasik, J. Gardner, J. Bates, D. Colombant, J. Weaver, Y. Aglitskiy*
9:40 - 10:00 AM	TO3	Y. Aglitskiy	Experimental Studies of Classical Richtmeyer-Meshkov and Non-Linear Rayleigh-Taylor Instabilities *Y. Aglitskiy, N. Metzler, A. L. Velikovich, M. Karasik, V. Serlin, A. J. Schmitt, S. Obenschain, J. H. Gardner*
10:00 - 10:20 AM	TO4	V. A. Smalyuk	Nonlinear Rayleigh-Taylor Growth Measurements on OMEGA *V. A. Smalyuk, O. Sadot, J. A. Delettrez, D. D. Meyerhofer, S. P. Regan, T. C. Sangster*

10:20 - 10:40 AM	TO5	P. Amendt	Bell-Plesset Effects for an Accelerating Interface with Contiguous Density Gradients in Ignition Double Shells *P. Amendt*
10:40 - 11:00 AM		Coffee Break	
<u>Oral Session: Direct Drive/Implosions</u>			Session Chair: S. Zalesak
11:00 - 11:20 AM	TO 6	T. C. Sangster	High Performance Direct-Drive Implosions Using Cryogenic D2 Fuel *T. C. Sangster, R. S. Craxton, J. A. Dellettrez, D. H. Edgell, R. Epstein, V. Yu. Glebov, V. N. Goncharov, D. R. Harding, D. Jacobs-Perkins, J. P. Knauer, S. J. Loucks, F. J. Marshall, R. L. McCrory, P. W. McKenty, D. D. Meyerhofer, P. B. Radha, S. P. Regan, W. Seka, V. A. Smalyuk, J. M. Soures, C. Stoeckl, J. A. Frenje, C. K. Li, R. D. Petrasso, F. H. Segun*
11:20 - 11:40 AM	TO7	S. P. Regan	Diagnosing Shock-Heated, Direct-Drive Plastic Targets with Spectrally Resolved X-ray Scattering *S. Regan, H. Sawada, T. R. Boehly, I. V. Igumenshchev, V. N. Goncharov, T. C. Sangster, D. D. Meyerhofer, B. Yaakobi, G. Gregori, D. G. Hicks, S. H. Glenzer, O. L. Landen*
11:40 - 12:00 PM	TO8	D.C. Wilson	Diagnostic Potential of a Full Range Reaction History Measurement for Ignition Capsules *D. C. Wilson, P. A. Bradley, M. R. Douglas, J. M. Mack, C. S. Young, R. A. Lerche, V. Yu. Glebov*
12:00 - 12:20 PM	TO9	R. S. Craxton	Polar-Direct-Drive Experiments on OMEGA Using Saturn Targets *R. S. Craxton, F. J. Marshall, M. J. Bonino, V. Yu. Glebov, J. P. Knauer, S. G. Noyes, W. Seka, V. A. Smalyuk*
12:20 - 12:40 PM	TO10	R. Epstein	Numerical Investigations of X-Ray Core Images from OMEGA Implosions Driven with Controlled Polar Illumination *R. Epstein, T. J. B. Collins, R. S. Craxton, J. A. Delettrez, I. V. Igumenshchev, F. J. Marshall, J. A. Marozas, P. W. McKenty, P. B. Radha, S. Skupsky, V. A. Smalyuk*
<u>Evening Invited Talk</u>			
7:30 - 8:30 PM	TI1	D. DuBois	Lessons from Ionospheric Excitation Experiments at Arecibo for Laser-Plasma Instability Studies *D. DuBois*
<u>Evening Poster Session</u>			
8:30 - 11:00 PM			
	TP1	K. Otani	Reduction of Rayleigh-Taylor Instability Growth with Cocktail Irradiation *K. Otani, K. Shigemori, T. Sakaiya, S. Fujioka, A. Sunahara, M. Nakai, H. Shiraga, H. Azechi, K. Mima*
	TP2	A. Casner	Planar Rayleigh-Taylor experiments on OMEGA *A. Casner, J-P. Jadaud, S. Liberatore, D. Galmiche, M. Vandenboomgaerde*
	TP3	C. C. Kuranz	Rayleigh-Taylor Instability in Decelerating Interface Experiments *C. C. Kuranz, R. P. Drake, K. K. Killibrew, D. J. Kremer, D. R. Leibrandt, E. C. Harding, H. F. Robey, B. A. Remington, B. Blue, H. F. Hansen, M. J. Edwards, A. R. Miles, J. P. Knauer, T. Boehly, D. Arnett*
	TP4	H. Sakagami	Rayleigh-Taylor Instability in Spherically Stagnating Systems *H. Sakagami, T. Okamoto, M. Horikoshi, K. Nishihara*
	TP5	A. B. Reighard	Collapsing Radiative Shock Experiments in Xenon on the Omega Laser *A. B. Reighard, R. P. Drake, K. K. Danneberg, D. J. Kremer, P. Susalla, M. Grosskopf, D. Leibrandt, T. Donajkowski, C. Muscatello, N. Meyer, S. G. Glendinning, T. S. Perry, B. A. Remington, R. J. Wallace, D. D. Ryutov, J. Greenough, J. Knauer, S. Bouquet, L. Boireau, M. Koenig, T. Vinci*
	TP6	J. Fahlen	High-Mach Number Relativistic Ion Acoustic Shocks *J. Fahlen, W. B. Mori*
	TP7	M. D. Rosen	When is 1/4 greater than 1/2? *M. D. Rosen*
	TP8	J. A. Cobble	Gas-Filled Hohlraum Drive with a Composite Laser Pulse Shape for Be Microstructure Experiments *J. A. Cobble, B. G. Devolder, N. M. Hoffman, D. C. Swift, T. E. Tierney, D. L. Paisley*

TP9	J. L. Milovich	Towards the Optimal Double-Shell Ignition Target via Careful Design and Experiments *J. L. Milovich, P. A. Amendt, M. M. Marinak, H. F. Robey*
TP10	A. B. Langdon	Beam Conditioning Mitigation of Laser Plasma Instabilities at the National Ignition Facility *A. B. Langdon, E. Williams, D. Hinkel, S. Dixit, R. Kirkwood, D. Munro*
TP11	B. Spears	Simulations of Radiographic Detection of NIF Ignition Capsule Defects *B. Spears*
TP12	M. J. Schmitt	Simulations of Laser-Generated High Energy Density Halfraum Environments *M. J. Schmitt, E. S. Dodd, G. R. Magelssen, I. L. Tregillis, S. R. Goldman, B. G. DeVolder*
TP13	O. Larroche	A Modified Hydrodynamics Model for Handling Plasmas Self-Collision in Numerical Simulations of ICF Hohlraums *O. Larroche*
TP14	J. C. Fernandez	A Comparison of Laser Backscattering Measurements in Quasi-Homogeneous Plasmas with Calculated Linear Gains for Stimulated Backscattering and Self Focussing Instabilities *J. C. Fernandez, D. S. Montgomery, B. B. Afeyan, A. J. Schmitt*
TP15	C. B. Schroeder	Vlasov, Fluid, and Particle Models of Low-Temperature, Collisionless, Relativistic Laser-Plasma Interactions *B. A. Shadwick, G. M. Tarkenton, C. B. Schroeder, E. Michel, E. Esarey*
TP16	E. C. Harding	A Simple Model for Microchannel Plate Output *E. C. Harding, R. P. Drake, J. L. Weaver*

Wednesday, June 29th

Oral Session: LPI/Parametric Instabilities			Session Chair: W. Seka
9:00 - 9:20 AM	WO1	T. Fouquet	Nonlinear Evolution of Stimulated Raman Scattering Driven by a RPP Laser Beam in a 2D Inhomogeneous Plasma *Th. Fouquet, S. Hüller, D. Pesme*
9:20 - 9:40 AM	WO2	D. Pesme	Two-Dimensional Simulations of Stimulated Brillouin Scattering *J. C. Adam, F. Detering, A. Heron, S. Hüller, P-E. Masson-Laborde, D. Pesme, C. Riconda*
9:40 - 10:00 AM	WO3	E. A. Williams	Demonstration of Polarization Dependent Backscatter in Multi-Beam Laser Plasma Interaction *R. K. Kirkwood, C. Niemann, A. B. Langdon, E. A. Williams, B. I. Cohen, L. Divol, S. H. Glenzer, L. J. Suter, O. L. Landen*
10:00 - 10:20 AM	WO4	C. B. Schroeder	Warm Wavebreaking of Nonlinear Laser-Driven Plasma Waves *C. B. Schroeder, E. Esarey, B. A. Shadwick*
10:20 - 10:40 AM	WO5	N. B. Meezan	Systematic Study of Laser-Plasma Instability Predictive Capability through Linear Gain Post-Processing of Radiation Hydrodynamics Simulations *N. B. Meezan, R. L. Berger, L. Divol, D. E. Hinkel, O. S. Jones, E. A. Williams, S. Glenzer, L. J. Suter*
10:40 - 11:00 AM	WO6	F. S. Tsung	Particle-in-Cell Simulations of the 2wp Instability *F. S. Tsung, W. B. Mori, B. B. Afeyan*
11:00 - 11:20 AM		Coffee Break	
Oral Session: Ionospheric Modification			Session Chair: D. S. Montgomery
11:20 - 11:40 AM	WO7	R. A. Jacobsen	The High Altitude Auroral Research Program (HAARP) Facility *R. A. Jacobsen, M. McCarrick, E. Kennedy, P. Kossey*
11:40 - 12:00 AM	WO 8	T. Pedersen	Artificial Optical Emissions Produced at the HAARP Facility *T. Pedersen, E. Gerken, M. Kosch, F. Djuth, E. Mishin, D. Sentman*
12:00 - 12:20 PM	WO9	B. Watkins	Combined Radar and Radio Observations of Ionospheric Modification Experiments at HAARP *B. Watkins, S. Oyama, W. Bristow, J. Hughes, C. Heinselman, P. A. Bernhardt, C. Siefring*
12:20 - 12:40 PM	WO10	C. L. Siefring	In Situ Diagnostics of HF Driven Non-Linear Plasma Interactions and Turbulence in the Ionosphere *C. L. Siefring, P. Rodriguez, P. Bernhardt, L. Gelinas, M. Kelley*
Conference Banquet			
7:30 - 10:00 PM		C. G. von Hillebrandt	Beyond the Beautiful Beaches: The Urgency and Challenges of Establishing a Tsunami Warning System in the Caribbean

Thursday, June 30th

Oral Session: Electron Transport/Modeling			Session Chair: R. S. Craxton
9:00 - 9:20 AM	RO1	V. N. Goncharov	Ablative Richtmeyer-Meshkov Instability as a Test of Thermal Conduction Models Used in Hydrosimulations of ICF Experiments *V. N. Goncharov, O. V. Gotchev, C. Cherfils-Clerouin*
9:20 - 9:40 AM	RO2	A. V. Maximov	Electron Heat Transport in the Laser Field in Direct-Drive ICF Plasmas *A. V. Maximov*
9:40 - 10:00 AM	RO3	R. G. Evans	Modeling of CPA Laser Heated Solids with the Implicit PIC Code LSP *R. G. Evans*
10:00 - 10:20 AM	RO4	D. Fisher	Transition from Periodic Lattice to Solid Plasma in Ultrashort Pulse Irradiation of Metals *D. Fisher, Z. Henis, E. Luzon, M. Fraenkel, S. Pecker, S. Eliezer*
10:20 - 10:40 AM	RO5	C. Blanchard	EOS and Electrical Conductivity of Warm Expanded Aluminum *C. Blanchard, G. Faussurier*
10:40 - 11:00 AM		Coffee Break	
Oral Session: Direct-Drive/Hydrodynamics			Session Chair: D. C. Wilson
11:00 - 11:20 AM	RO6	A. Bar-shalom	A New Approach for Calculating Electronic Pressure in Plasmas *A. Bar-Shalom, J. Oreg*
11:20 - 11:40 AM	RO7	N. Metzler	Modeling of Nike Experiments of Acceleration of Planar Targets Stabilized with a Short Spike *N. Metzler, A. L. Velikovich, A. J. Schmitt, J. H. Gardner, J. L. Weaver*
11:40 - 12:00 PM	RO8	J. Weaver	Investigations of Accelerated Targets Stabilized by a Short Spike Prepulse at the Nike KrF Laser Facility *J. Weaver, N. Metzler, A. L .Velikovich, J. Oh, Y. Aglitskiy, M. Karasik, A. N. Mostovych, V. Serlin, J. H. Gardner, S. Obenschain, A. J. Schmitt*
12:00 - 12:20 PM	RO9	A. E. Koniges	Techniques for Enabling Late-Time Simulations of ICF Target Configurations *A. E. Koniges, R. W. Anderson, P. Wang, B. T. N. Gunney, N. Elliot, D. C. Eder*
Business Meeting			
12:20 - 1:00 PM			
Evening Invited Talk			
7:30 - 8:30 PM	RI1	J. Faure	Generation of High Quality Monoenergetic Electron Beams from Ultra-Intense Laser-Plasma Interaction *J. Faure, Y. Glinec, V. Malka, J. Santos, F. Burgy, T. Hosokai, A. Pukhov, S. Kiselev, S. Gordienko*
Evening Poster Session			
8:30 - 11:00 PM			
	RP1	V. Stefan	Pellet Core Heating via High Harmonic Electron Bernstein modes in Fast Ignition Laser Fusion *V. Stefan*
	RP2	V. Stefan	Quasi-Stationary B-Fields Generation due to Weibel Instability in Fast Ignition Laser Fusion Pellets *V. Stefan*
	RP3	R. J. Mason	Features of the ANTHEM Code for Fast Ignition *R. J. Mason*
	RP4	A. Sunahara	Nonlocal Electron Transport in Laser-Produced Plasmas *A. Sunahara, K. Mima*
	RP5	W. Manheimer	Models of Electron Transport in Laser Produced Plasmas *D. Colombant, W. Manheimer*
	RP6	T. Nakamura	Electron Lateral Transport and Surface Field Generation by Oblique Incident Laser Pulse *T. Nakamura, H. Sakagami, K. Kima, T. Johzaki, H. Nagatomo*
	RP7	A. Heron	Dispersion and Transport of Energetic Particles Created during the Interaction of Intense Laser Pulses with Over Dense Plasma *J. C. Adam, A. Heron, G. Laval*
	RP8	T. J. T. Kwan	Particle Simulation of Ion Acceleration from the Interaction of Ultra-Intense Laser with Solid Density Targets *B. J. Albright, L. Yin, T. J. T. Kwan, K. J. Bowers, B. M. Hegelich, J. C. Fernandez*
	RP9	E. S. Dodd	Modeling of Fast-Ion Production from Short-Pulse Laser-Matter Interactions *E. S. Dodd, K. Flippo, R. J. Mason*

RP10	A. S. Moore	Integrated Absorption-Energy Transport Measurements from Ultra-Intense Laser Heating of Atomic Clusters *A. S. Moore, E. T. Gumbrell, P. Nilson, J. Lazarus, E. L. Clark, R. M. Stevenson, R. A. Smith*
RP11	W. B. Mori	Laser Wakefield Acceleration in the Blowout or Bubble Regime: A Path Towards a TeV Stage *W. Lu, M .Tzoufras, F. S. Tsung, C. Huang, C. Joshi, W. B. Mori, L. O. Silva, R. Fonseca*
RP12	B. Bezzerides	Inflation Threshold II: Analytic Calculations and Application of Nonlinear Threshold for Enhanced Backward Raman Scattering due to Trapping *B. Bezzerides, D. F. DuBois, H. X. Vu*
RP13	D. DuBois	Thomson Scatter Spectra from Ionospheric Excitation Experiments and Their Relevance for Forward SRS in Laser-Plasma interactions *D. DuBois, H. X. Vu, B. Bezzerides*
RP14	D. J. Strozzi	Interplay of Electron Trapping and Inhomogeneity in Raman Scattering *D. J. Strozzi, A. Bers, E. A. Williams, A. B. Langdon*
RP15	G. Pollack	Development of an X-ray Diagnostic Raytrace Postprocessing Code for Unstructured ASC Codes *G. Pollack, B. Clark*

Friday, July 1st

Oral Session: LPI			Session Chair: B. Afeyan
9:00 - 9:20 AM	FO1	R. W. Short	Microinstabilities of Relativistic Electron Beams in Plasmas *R. W. Short, J. Myatt*
9:20 - 9:40 AM	FO2	R. L. Berger	Scaling of Laser Interactions with Plasmas from High-Z Gasbags *R. L. Berger, C. Constantin, L. Divol, N. Meezan, C. Niemann, L. J. Suter*
9:40 - 10:00 AM	FO3	M. R. Dorr	p3Fd Simulations of Smoothed Laser Beam Propagation Through NEL Gaspipes *M. R. Dorr, R. L. Berger, L. Divol, C. H. Still, E. A. Williams, D. H. Froula, S. H. Glenzer, O. S. Jones*
10:00 - 10:20 AM	FO4	L. Divol	Reduction of Backscatter in Long Plasma with Beam Smoothing in the Moderate Gain Regime *L. Divol, E. A. Williams, R. L. Berger, D. Hinkel*
10:20 - 10:40 AM	FO5	E. A. Williams	Laser Plasma Interactions in De-focussed Laser Beams *E. A. Williams, A. B. Langdon, L. Divol*
10:40 - 11:00 AM		Coffee Break	
Oral Session: NIF			Session Chair: Y. Aglitskiy
11:00 - 11:20 AM	FO6	E. S. Dodd	Temporal Anti-Correlation of SRS and SBS *E. S. Dodd, B. Bezzerides, D. F. DuBois, H. X. Vu*
11:20 - 11:40 AM	FO7	H. X. Vu	Inflation Threshold: A Nonlinear Threshold for Enhanced Backward Raman Scattering Due to Trapping *H. X. Vu, B. Bezzerides, D. F. DuBois*
11:40 - 12:00 PM	FO8	O. S. Jones	Recent Evidence for Increased Radiation Drive in U:Au: Dy Cocktail Hohlraums *O. S. Jones, J. Schein, M. D. Rosen, L. J. Suter, R. J. Wallace, J. Gunther, K. M. Campbell*
12:00 - 12:20 PM	FO9	D. C. Eder	Damage Mitigation on NIF Using Shields and Target Redesign *D. C. Eder, P.K. Whitman, A. E. Koniges, R. W. Anderson, P. Wang, B. T. Gunney, T. G. Parham, J. G. Koerner, S. N. Dixit, T. I. Suratwala, B. E. Blue, J. F. Hansen, M. T. Tobin, H. F. Robey, M. L. Spaeth, B. J. MacGowan*
12:20 - 12:40 PM	FO10	C. Niemann	2w Beam Propagation in Large-Scale Length Plasmas at NIF-like Temperatures *C. Niemann, L. Divol, D. H. Froula, G. Gregori, O. Jones, R. K. Kirkwood, J. D. Moody, J. S. Ross, C. Sorce, R. Bahr, S. H. Glenzer*

Monday, June 27th, 2005

8:45 -	9:00 AM	Welcome/ Opening Remarks Conference Organizing Committee
9:00 -	10:40 AM	Oral Session: LPI/Parametric Instabilities Session Chair: A. J. Schmitt
10:40 -	11:00 AM	Coffee Break
11:00 -	12:40 PM	Oral Session: Ultra-Short Pulse Session Chair: F. S. Tsung
7:30 -	8:30 PM	Evening Invited Talk Gas-Filled Hohlraum Experiments at the National Ignition Facility J. C. Fernandez
8:30 -	11:00 PM	Evening Poster Session

Oral Session 1

Laser Plasma Interactions/ Parametric Instabilities

Session Chair: A. J. Schmitt

9:00 - 10:40 AM

35th[d] Annual Anomalous Absorption Conference
Fajardo, Puerto Rico
June 26th - July 1st, 2005

MO1

The Physics of KEEN Waves in Laser Produced Plasmas*

Bedros Afeyan,[1] V. Savchenko,[1] K. Won,[1] T. Johnston,[2] A. Ghizzo,[3] P. Bertrand,[3] J. Kline,[4] Bertche, [5] N. Kurnit,[4] D. Montgomery,[4] C. Niemann[6]

[1]*Polymath Research Inc.,* [2]*INRS-Energie-Materiaux,* [3]*U. Henri Poincare',* [4]*LANL,* [5]*UC Berkeley,* [6]*LLNL*

We will present Vlasov simulations, theoretical ideas and experimental results on the optical mixing generation of Kinetic Electrostatic Electron Nonlinear (KEEN) waves[1] in the presence or absence of strong stimulated Raman scattering (SRS) of the pump wave. The simulations will emphasize the exposition of the physics of KEEN waves such as the crucial wave-trapped-particle interactions which are self-consistently evolving and can be nonlocal in nature. The single potential well localized static equilibrium which is the key to the construction of BGK modes will be shown to be less likely than dynamical equilibria (of which KEEN waves are examples) where particles trap and detrap multiple times exchanging energy with the waves not just locally in space and chaotically in time.

We will also show the evidence for ponderomotively driven structures in plasmas in the spectral gap of linear plasma wave theory. We will show the results of our most recent campaign on Trident where KEEN wave direct Thomson scattering and transmission beam diagnostic measurements of a Raman cell converted Orange beam were simultaneously recorded and their time evolution matched against the Raman backscatter of a Green pump wave with two different phase plates which gave rise to two different filamentation levels. We varied Green-Orange overlap times as well as Orange beam intensities to map the duration of excited KEEN waves and their possible interactions with the plasma waves generated by the SRS of the pump.

[1] B. Afeyan, et al., Kinetic Electrostatic Electron Nonlinear (KEEN) Waves and their interactions driven by the ponderomotive force of crossing laser beams, Proc. IFSA, (Inertial Fusion Sciences and Applications 2003, Monterey, CA), B. Hammel, D. Meyerhofer, J. Meyer-ter-Vehn and H. Azechi, editors, 213, American Nuclear Society, 2004.

*This work was supported by the DOE SSAA PRI Grant DE-FG03-3NA00059 and the LANL and LLNL.

Prefer Oral Presentation.

35th Annual Anomalous Absorption Conference
Fajardo, Puerto Rico
June 26th – July 1st, 2005

Thomson Scattering Detection of Ponderomotively Driven Kinetic Electrostatic Electron Nonlinear (KEEN) Waves in a Laser Produced Plasma

J. L. Kline,[1] B. B. Afeyan,[2] W. A. Bertsche,[3] R. P. Johnson,[1] N. A. Kurnit,[1]
D. S. Montgomery,[1] V. Savchenko,[2] K. Won,[2] and C. Niemann[4]

[1] *Los Alamos National Laboratory, Los Alamos, NM 87545*
[2] *Polymath Research, Inc, Pleasanton, CA, 94566*
[3] *University of California at Berkeley, Berkeley, CA 94720*
[4] *Lawrence Livermore National Laboratory, Livermore, CA, 94550*

Vlasov-Poisson simulations using ponderomotively driven excitations have discovered the existence of stable, nonlinear, multimode coherent structures in plasmas named Kinetic Electrostatic Electron Nonlinear (KEEN) waves.[1] For a given wave number drive, they seem to form and persist for any drive frequency in a large region of (ω,k) space. Experiments at the Trident laser facility, jointly conducted by Polymath Research Inc. and LANL, have been performed to verify these findings. The two lasers used had 527 and 600 nm wavelengths which is predicted to drive waves in the proper KEEN wave excitation band.[1] A Raman cell was developed and fielded on the TRIDENT Laser to convert a 527 nm laser beam to 600 or 697 nm as needed, via first or second Stokes emission in N_2 gas. Using two beams at these wavelengths, KEEN waves have been driven and detected with both 263 and 351 nm Thomson scattering in a Nitrogen plus Hydrogen gas jet plasma. This presentation will cover experimental conditions and diagnostic attributes associated with the detection of KEEN waves.

Supported by DOE Academic Alliance Grant DE-FG03-03NA00059 and LANL under Contract No. W-7405-ENG-36.

[1] Afeyan et al., "Kinetic electrostatic electron nonlinear (KEEN) waves and their interactions driven by the ponderomotive force of crossing laser beams", Third International Conference on Inertial Fusion Sciences and Applications, Monterey, CA, United States, 264 (2003) and presented at this conference

LA-UR-05-3177

35th Annual Anomalous Absorption Conference
Fajardo, Puerto Rico
June 26th – July 1st, 2005

Evidence of a Nonlinear Dispersion Relation for Langmuir Waves?

D.S. Montgomery, J.L. Kline
Los Alamos National Laboratory
Los Alamos, NM 87545

Experiments are performed using the single hot spot configuration on the Trident laser facility to study stimulated Raman scattering (SRS) in order to better understand the nonlinear growth and saturation of this instability. SRS is the parametric decay of an intense laser light wave into a scattered light wave and a Langmuir wave (LW). The LW frequency and wave number (ω, k) are inferred both from the SRS scattered light spectrum, and from Thomson scattering of the driven LW. In addition, Thomson scattering from thermal-level ion wave fluctuations is used to infer the time-dependent plasma conditions. In the experiment, the plasma temperature drops from 700 to 500 eV while the LW is driven by SRS, thus providing a time-dependent change of $k\lambda_D$. Further evidence indicates that an assumption of constant electron density during this time is valid. Using these plasma conditions, the inferred LW dispersion is compared to the linear kinetic dispersion relation. At $k\lambda_D \sim 0.34$, the LW frequency is ~ 6.5% lower than that predicted by the usual linear dispersion relation. However, (ω, k) inferred from the experimental data compare favorably to the nonlinear dispersion relation of Rose and Russell [*Phys. Plasmas* **8**, 4784 (2001)] for a LW average amplitude $e\Phi/T_e \sim 0.6$.

Work performed under the auspices of the NNSA by Los Alamos National Laboratory under Contract No. W-7405-ENG-36.

Bare-Bones Langmuir Wave Model in Kinetic Regime

Harvey A. Rose
Los Alamos National Laboratory

Abstract†

Electrons trapped by a Langmuir wave (LW), with amplitude ϕ and wavenumber k, cause a frequency shift, $\Delta\omega(k,\phi) < 0$, which becomes significant [*e.g.*, its associated self-focusing (SF) instability threshold may fall below LDI's] at $k\lambda_D \approx 0.3$. This nonlinear dispersion relation and rotational invariance lead to ϕ envelope dynamics *with no wiggle room* in its conservative terms: group velocity, $\mathbf{v}_g$, perpendicular diffraction coefficient, $D_\perp$, *and hyper-diffraction* coefficient, $D_{Hd} < 0$, are determined. LW SF, which requires $\Delta\omega \times \left[D_\perp (\delta k)^2 + D_{Hd} (\delta k)^4 \right] < 0$, is thus limited to moderate values of δk ($\delta\mathbf{k}\cdot\mathbf{v}_g = 0$). The fact that $D_\perp$ goes negative for large $|\phi|$ limits LW SF to moderate values of $|\phi|$. Rotational invariance, which implies $v_g \propto D_\perp$, together with $\partial D_\perp / \partial |\phi| < 0$, would lead to shock formation unless diffraction parallel to $\mathbf{v}_g$, with coefficient $D_\parallel$, is also included. These basic structural features, nonlinear $\Delta\omega < 0$, nonlinear $\mathbf{v}_g$, and finite $D_\parallel < 0$, imply a novel LW structure, a BGK mode kink: it consists of two otherwise uniform, identical, BGK modes connected by a region across which there is a net change of phase. Since the LW phase velocity in general differs from the kink velocity, this time independent (in the kink frame) solution for ϕ's envelope implies time periodic ϕ. The results of 1D numerical Vlasov-Poisson simulations, which seek to test the existence of such solutions, will be presented.

† For oral presentation at 35th Annual Anomalous Absorption Conference, June 26 - July 1, 2005, Fajardo, Puerto Rico.

Various Forms of Stimulated Brillouin Scattering in Long-Scale-Length Plasmas Relevant to Direct-Drive Inertial Confinement Fusion

W. Seka, H. Baldis*, A. V. Maximov, J. Myatt, R. W. Short, R. S. Craxton, R. E. Bahr, and T. C. Sangster

Laboratory for Laser Energetics, University of Rochester
250 East River Road, Rochester, NY 14623-1299
*Department of Applied Science, University of California, Davis, CA 94550.

Stimulated Brillouin scattering (SBS) has been investigated for many years using the 60-beam OMEGA (UV) Laser System at the Laboratory for Laser Energetics. The experiments use planar CH targets irradiated by a number of beams to produce long-scale-length plasmas followed by one or more interaction beams with smoothing by spectral dispersion (SSD) and polarization smoothing (PS). The experimental signatures of SBS indicate distinct regions in density where SBS is detected. Typically, a rapid exponential SBS growth is observed above an intensity threshold of $\sim 5 \times 10^{13}$ W/cm^2, rising from a detection threshold reflectivity of R_{SBS} $\sim 10^{-5}$ to $\sim 10^{-2}$ around 2×10^{14} W/cm^2. Above this intensity, the SBS reflectivity increases approximately linearly. Depending on the plasma and irradiation conditions, one observes SBS growth from thermal noise levels in the underdense plasma or seeded SBS near the turning point of the interaction beam(s). Hot-spot–driven SBS is clearly identified using interaction beams with or without PS while filamentation is suppressed by the application of SSD (1-THz$_{UV}$ bandwidth).

Simulations using *pf3d* for SBS in the underdense corona and a code with a full Maxwell solver near the turning point help explain these observations and strengthen the general understanding of SBS under conditions relevant to current and future direct-drive ICF experiments.

This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC52-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

Prefer oral presentation

Oral Session 2

Ultra-Short Pulse Lasers

Session Chair: F. S. Tsung

11:00 - 12:40 PM

Abstract for an Oral Presentation at the 35th Anomalous Absorption Conference, Fajardo, Puerto Rico, June 26 - July 1, 2005

Electron acceleration, THz and x-ray generation in short-pulse laser-plasma experiments at LBNL

E. Esarey,† C. Filip,† C.G.R. Geddes,‡ A.J. Gonsalves,‡ S. Hooker,‡ E. Michel,† P. Michel, B. Nagler, K. Nakamura,* C.B. Schroeder, C. Toth, J. van Tilborg** and W.P. Leemans†

LOASIS Program, Lawrence Berkeley National Laboratory,
University of California, Berkeley, CA 94720

Recent experimental results using the 10 and 100 TW laser systems of the LOASIS Program at LBNL will be discussed. This includes the production of high-quality electron beams (a few 10^9 electrons, a few percent energy spread, with energies above 80 MeV) from a laser wakefield accelerator that operated in a regime in which the acceleration length was matched to the length over which accelerated electrons outran (dephased from) the wake.[1,2] A plasma channel, created by a hydrodynamical shock produced by an igniter and heater laser pulses, was used to guide a relativistically intense ($> 10^{18}$ W/cm^2) laser pulse over more than 10 diffraction lengths.[3] Coherent THz radiation, produced when the accelerated electron bunch crosses the plasma-vacuum boundary,[4,5] was measured using an electro-optic technique.[6] The measured THz waveform confirms the production of electron bunches < 50 fs in duration. Preliminary results on the production of x-rays by the betatron motion of the electron bunch within the plasma channel, and by the Thomson scattering of a laser pulse off the electron bunch, will be reported. Guiding of the 30-100 TW lasers pulses in a long (few cm) plasma channel produced by a capillary discharge will also be discussed.

This work supported by DoE, Division of High Energy Physics, under contract number DE-AC03-76SF00098.

†Also at the Department of Physics, University of Nevada, Reno.

‡Department of Physics, Oxford University, United Kingdom.

*Also at the University of Tokyo, Japan.

**Also at the Technische Universiteit Eindhoven, the Netherlands.

[1] C.G.R. Geddes et al., Nature **431**, 538-541 (2004).

[2] C.G.R. Geddes et al., Phys. Plasmas **12**, 056709 (2005).

[3] C.G.R. Geddes et al., Phys. Rev. Lett., submitted.

[4] W.P. Leemans et al., Phys. Rev. Lett. **91**, 074802 (2003).

[5] C.B. Schroeder et al., Phys. Rev. E **69**, 016501 (2004).

[6] J. van Tilborg et al., Phys. Rev. Lett., submitted.

35th Annual Anomalous Absorption Conference
Fajardo, Puerto Rico
June 27 – July 1, 2005

MO7

Target Configuration Influences on Short-Pulse Laser-Matter Interactions

R. J. Mason†, E. S. Dodd and B. J. Albright
Applied Physics Division, Los Alamos National Laboratory, Los Alamos, NM 87545

We study the interaction of intense short pulse lasers with target foils under a variety of incident density profile conditions. We focus on hot electron retention near the surface of foils with either steep or mild density profiles facing a 1.06 micron laser delivering, typically, 4 x 10^{19} W/cm^2. Steep profiles, rising to $\geq 10^{23}$ electrons/cm^3 over a few microns, develop strong thermoelectric B-fields, which retain hot electrons near the spot and spread them laterally by *E x B* drift out along the target high density surface. Conversely, mild profiles rising from 10^{20} e^-/cm^3 to the peak density over $\geq$30 μm tend to lock the emitted hot electrons into a spot-sized ball near the critical surface. Targets prepared by a prepulse to have density foot over 30 μm, joining the foil at ~3-5 n_{crit}, exhibit foot steepening over 200 fs until the critical surface has been pushed to the steep foil interface; subsequently, the electron retention and surface drift scenario prevails. We calculate with the implicit 2D hybrid code ANTHEM[1]. The mesh is fixed, with separate Van Leer Eulerian fluids describing the ions and cold electrons of the background plasma. PIC hot electrons scatter against the ions, and drag against the cold background electrons. To mock up the resistive behavior in metals the cold electrons undergo temperature-capped Spitzer resistive collisions with the ions. Energy from the light is dumped at the critical surface after delivery by a grid-following scheme. The *E- and B*-fields are computed via the Implicit Moment Method[1]. For economy, most of the calculations were performed with 0.5 to 1 μm sized computational cells, as implicitness permits. Convergence studies with cells as little as 0.02 μm wide show little difference in the global interaction, although Weibel-like density fingers 0.3 μm wide appear below relativistic critical (n_{crit}/γ), yet fail to penetrate more deeply.

†Also at the Research Applications Corporation, Los Alamos, NM
Email: mason@lanl.gov, rodmason01@msn.com
Tel: (505)-667-5524, (505)-672-1938; FAX: (505)-665-7725, (505)-672-0058

1. R. J. Mason and C. W. Cranfill, IEEE Trans. Plasma Sci. **PS-14**, 45 (1986); R. J. Mason, J. Comp. Phys. **71**, 429 (1987).

*Work supported by the USDOE.

Preference: Oral Presentation

MO~~8~~ 9

35th Anomalous Absorption Conference 2005

Laser-Produced Heavy Ions via Target Laser-Ablation-Cleaning and Proton Acceleration Suppression

K. Flippo, B. M. Hegelich, M. J. Schmitt, E. Dodd, J. A. Cobble, D. C. Gauthier, R. Gibson, R. Johnson, S. Letzering, J. C. Fernández

Los Alamos National Laboratory, PO Box 1663, MS E526, Los Alamos, NM 87545

T. Lin, A. Maksimchuk, M. Rever[§], D. Umstadter[§]
FOCUS Center, University of Michigan, Ann Arbor, 48105

e-mail: kflippo@lanl.gov

Abstract:

In the last few years it has become apparent that the surface contamination on laser ion-acceleration targets is a major impediment to the acceleration of the actual target ions. To this end we have performed experiments at the Los Alamos Trident Laser facility using one arm of the Trident laser at 150 ps to ablatively clean the target's rear-surface, then the front-surface is subsequently irradiated by the Trident TW Short-pulse arm to accelerate the bulk-target heavy-ions to high energies. This process was used on targets consisting of 15 microns of either vanadium, or copper. The 150 ps pulse rids the rear of the target of its omnipresent surface contamination layer, consisting mainly of water vapor and hydrocarbons, and allows the Trident TW Short-pulse arm to illuminate the target and accelerate ions via the Target Normal Sheath Acceleration (TNSA) mechanism from the rear cleaned surface. The lower energy component from the front surface is also present and has been observed experimentally and modeled recently with the TRISTAN PIC code. Mitigation of this component is discussed. Normally ions with the lightest charge to mass ratio (i.e. protons) would be accelerated preferentially from both surfaces at the expense of heavier ions. However, with the rear contamination layer removed, and hence the bulk of the available high energy protons, the TNSA mechanism is available to accelerate the bulk material ions to high energies. Our experimental results are compared to the LASNEX code to validate and improve our predictive capabilities for future acceleration experiments.

[§] Currently at the University of Nebraska, Lincoln.

MO9 8

Material- and temperature dependence on species and spectral properties of laser-accelerated ions

B. M. Hegelich[1], K. Flippo[1], B. J. Albright[1], J. Cobble[1], C. Gautier[1], R. Johnson[1], S. Letzring[1], M. Paffett[1], R. Schulze[1], J. C. Fernandez[1]

P.O. Box 1663, MS E526
Los Alamos National Laboratory
Los Alamos, New Mexico 87544

hegelich@lanl.gov
phone: 505-667-6989
fax: 505-665-3552

Topic: Ultrashort pulse interactions / Laser Particle Acceleration
Type: oral

Laser-induced ion acceleration, until recently, has been poorly controlled. In this paper, we present our increased understanding of the profound effect of the surface conditions of the target on the resulting ion-beam characteristics. Specifically, we describe the results from our latest experiments aimed at increasing the control over the ion species, its charge state and its energy spectrum. These experiments have been performed at the Los Alamos National Laboratory Trident Laser Facility. Focusing the ~30 TW Trident laser pulse on a thin (~20μm) metal foil target, a range of different ions, from hydrogen (Z=1) over carbon (Z=5) up to palladium (Z=46) have been accelerated to multi-MeV/nucleon energies. Until recently, both the energy spectrum and the charge state distribution have been neither very well controlled nor their origin fully understood. Using a variety of different target materials, some of which have a special catalytic surface chemistry, and a new, better controlled heating technique, we performed detailed studies of the effects of target conditions, at the time of the laser interaction, on the properties of the accelerated ions. Depending on material and temperature, the dominantly accelerated species, its charge state and its energy spectrum can be changed. The targets are heated by a Nd:YVO laser delivering up to 5W CW at 532nm. Using a four-wavelength pyrometer, we obtain a precise temperature measurement of the target right before the short-pulse laser interaction. This temperature can then be correlated to the charge state distribution and energy spectra of the laser accelerated ion, which are measured by two Thomson parabola (TP) spectrometers looking at 0° and 10° with respect to target normal. These systematic (TP) measurements, at 2 different angles simultaneously, enable us to recover information on the spatial ion distribution for given laser and target conditions. Otherwise, trying to measure the variation of ion-beam conditions in space with a single TP spectrometer using multiple shots with identical conditions would be exceedingly difficult, given the normal shot-to-shot fluctuations in ultrahigh-power laser systems. The data obtained in the experiments will than be used to expand our predictive capability, from that embodied in our current 1D hybrid model of the ion acceleration, to a 2D and later a full 3D model.

Abstract for a Poster Presentation at the 35th Anomalous Absorption Conference, Fajardo, Puerto Rico, June 26 - July 1, 2005

Nonlinear group velocity, pump depletion, and electron dephasing in short-pulse laser-plasma interactions

Eric Esarey,[†] C.B. Schroeder, B.A. Shadwick[‡] and W.P. Leemans[†]

LOASIS Program, Lawrence Berkeley National Laboratory, University of California, Berkeley, CA 94720

The nonlinear evolution of sub-ps laser pulses in underdense plasmas is analyzed for arbitrary laser intensity. Some of the new results derived include expressions for the nonlinear group velocity of the laser pulse, the nonlinear phase velocity of the wakefield, the nonlinear frequency shift, and the laser pulse envelope distortion. New scaling laws are presented for the pump depletion length and the electron dephasing length, which are of interest to laser wakefield accelerators.[1,2] Analytical results are compared to numerical calculations based on fluid models. In the low laser intensity limit, the depletion length is much longer than the dephasing length, thus implying that some form of phase matching is necessary. In the high intensity limit, the depletion and dephasing lengths are approximately equal, thus allowing for high efficiency coupling of laser energy to the wake and the accelerated particles. Implications for an optimized design of a 1 GeV accelerator stage are discussed.

This work supported by DoE, Division of High Energy Physics, under contract number DE-AC03-76SF00098.

[†]Also at the Department of Physics, University of Nevada, Reno.

[‡]Also at the Institute for Advanced Physics, Conifer, CO.

[1]C.G.R. Geddes et al., Nature **431**, 538-541 (2004).

[2]C.G.R. Geddes et al., Phys. Plasmas **12**, 056709 (2005).

Evening Invited Talk 1

Gas-Filled Hohlraum Experiments at the National Ignition Facility

J. C. Fernandez

7:30 - 8:30 PM

Gas-filled hohlraum experiments at the National Ignition Facility*

J. C. Fernández, S. R. Goldman, J. L. Kline, C. Gautier, G. P. Grim, B. M. Hegelich, D. S. Montgomery, N. Lanier, H. Rose, J. B. Workman,
Los Alamos National Laboratory, Los Alamos, NM 87544, USA
D. Braun, K. Campbell, E. Dewald, S. Glenzer, D. Hinkel, J. Holder, D. Kalantar, J. Kamperschroer, J. Kimbrough, R. Kirkwood, O. Landen, B. MacGowan, A. MacKinnon, J. McDonald, C. Niemann, J. Schein, M. Schneider, L. Suter, B. Young,
Lawrence Livermore National Laboratory, Livermore, CA 94550, USA

A limited set of experiments have been done with a Quad (4 beams) of the National Ignition Facility (NIF) laser at the Lawrence Livermore National Laboratory (LLNL), to study a gas-filled hohlraum design[1] developed at LANL. As used here, a NIF Quad can be considered roughly as a single *f/8* beam. To be qualitatively consistent with ignition targets, we used a highly shaped pulse of about 8 ns in duration, with a low power foot and a late peak of 7 TW, for a total energy of 14 kJ. The hohlraum gas-fill is intended to provide plasma pressure to tamp the hohlraum gold wall, to avoid hohlraum filling, during the relatively long period while the laser is on, just as in existing ignition-hohlraum designs. Our target design is of the``halfraum'' type – it has only one laser-entrance hole, ideal for single-sided illumination geometries such as the NIF Quad when efficient conversion to x-ray drive is desired. While the experiments had multiple purposes, we concentrate here on the opportunity to deploy an array of diagnostics on a hohlraum-plasma with many features that are relevant for ignition hohlraums. Diagnostics deployed in these experiments include laser energy and power; back-scattered light spectrum, power and energy directly into the laser-focusing lens; back-scattered laser light energy outside the lens; soft x-ray drive spectrum and power, and; gated framing-camera images of the hohlraum self-emission with x-ray energy > 10 keV. The results will be presented, along with justification of our conclusion that the capability to measure the *power* of the back-scattered light outside the laser-focusing lens should be added for future NIF experiments with ignition targets.

Although these targets are not designed as a direct emulator of NIF hohlraums, our measurements allow another test of our modeling capabilities and of our understanding of the performance of this type of hohlraum. In fact, a large number of radiation-hydrodynamics simulations with the LASNEX code were necessary to get a comprehensive picture of the hohlraum energetics that is consistent with the available measurements. As in any challenging scientific program, some of our results are surprising, especially in the area of laser-plasma instabilities (LPI). Our prior empirical rules regarding which ion plasma compositions favor stimulated Raman scattering (SRS) and which ones favor Brillouin scattering (SBS) do not hold in these NIF experiments. SBS was always dominant, (≈ 25% reflectivity), resulting in a measurable decrease in the x-ray drive. In spite of the many recent significant advances in our theoretical understanding of LPI in relevant regimes, we do not fully understand these NIF gas-filled hohlraum results, nor the reasons for the differences relative to prior experiments. Thus we conclude that LPI is a significant concern for hohlraum energetics that requires further and vigorous study. These results and remaining questions are presented in this paper.

* This work supported by the NNSA of the US DOE.

[1] S. Robert Goldman *et al.*, this conference

Corresponding author: Juan C. Fernández, Los Alamos National Laboratory, MS E526, Los Alamos, NM 87544, USA; juanc@lanl.gov; FAX: 1 505 665 4409

Evening Poster Session 1
8:30 - 11:00 PM

Collective FSBS: Influence of High Z Dopant MP1

Pavel Lushnikov
University of Notre Dame and Los Alamos National Laboratory

Harvey A. Rose
Los Alamos National Laboratory

Abstract[†]

ICF has always had, as one of its dominant constraints, the control of laser beam propagation. Beam and plasma parameters have been empirically adjusted to be on the edge of losing such control, consistent with the fact that nominal NIF parameters (assuming low Z plasma so that *thermal effects are a correction*) are near the forward SBS (FSBS) threshold (Lushnikov and Rose, L&R[‡]). It will be shown that being on this instability edge can be used as a control lever: a small amount of high Z dopant may lead to qualitative change in FSBS regime at fixed laser intensity, possibly reducing backscatter instability losses[§].

An intermediate regime has been revealed (L&R) *for ponderomotive driven* FSBS, through analytic and simulation methods, in which the beam angular diffusion rate is much greater than that below the FSBS threshold, *with beam fluctuations remaining nearly Gaussian.* This implies beam propagation nearly as in vacuum, except that the beam's f/#, F, decreases with increasing propagation distance through plasma. Since backscatter instabilities, in the strongly damped convective regime, have a much lower (linear) intensity threshold[**], $\langle I \rangle_{th}$, in smoothed beams than in a coherent beam, due to large speckle intensity fluctuations, with $\langle I \rangle_{th} \propto 1/F^2$, their thresholds increase with propagation in the intermediate FSBS regime.

Passage through various *ponderomotive* FSBS regimes is controlled by the parameter $\tilde{I}_0 = F^2 \left(v_{osc}/v_e \right)^2 \left(n_e/n_c \right) \left(1/\nu_i \right)$, with ν_i the dimensionless ion acoustic damping coefficient. Analytical results will be presented which show a decrease of $\tilde{I}_0$'s FSBS threshold value through the addition of small amounts of high Z dopant.

[†] For poster presentation at 35th Annual Anomalous Absorption Conference, June 26 - July 1, 2005, Fajardo, Puerto Rico.
[‡] Pavel M. Lushnikov and Harvey A. Rose, Phys. Rev. Lett. **92**, 255003 (2004).
[§] Such results have already been observed, but absent SSD, a key aspect of our theory: R. M. Stevenson *et al.*, Phys. Plasmas **11**, 2709 (2004); L. J. Suter *et al.*, 2738, *ib.*
[**] H. A. Rose and D. F. DuBois, Phys. Rev Lett. **72**, 2883 (1994).

Annual Anomalous Absorption Conference
Fajardo, Puerto Rico
June 26-July 1, 2005

Two-dimensional Simulations of Stimulated Brillouin Backscattering: Effects of Ion-ion Collisions and Inhomogeneity*

Bruce I. Cohen, A. Bruce Langdon, Laurent Divol, and Edward A. Williams
University of California Lawrence Livermore National Laboratory
P.O. Box 808, Livermore, CA 94550

Two-dimensional simulations of stimulated Brillouin scattering with the BZOHAR[1] code have been extended to examine the influences of ion-ion collisions and inhomogeneity (*e.g.*, spatial nonuniformity in the mean ion flow). In recent work,[2] BZOHAR hybrid simulations (particle-in-cell kinetic ions and Boltzmann fluid electrons) showed that the saturation of stimulated Brillouin backscattering (SBBS) was dominated by ion trapping effects and secondary instability of the SBBS primary ion wave (decay into subharmonic ion waves and ion quasi-modes). Because ion-ion collisions damp ion acoustic waves (increased damping decreases the linear SBBS gain), decorrelate and detrap resonant ions, and tend to relax the ion velocity distribution back to a Maxwellian, one expects that ion-ion collisions can influence the saturation of SBBS significantly, particularly over collisional timescales.[3] Here we report results of a systematic study of SBBS saturation in two dimensions including ion-ion collisions. We employ the simple and efficient Langevin ion collision algorithm introduced in Ref. 4. Because the drag and diffusion coefficients in Ref. 4 have no dependence on the velocity of the test particle and only depend on the local plasma density and ion temperature, we also consider the more sophisticated Langevin collision algorithm of Ref. 5, which represents a more complete, Fokker-Planck collision operator that depends on the speed of the test particle.

Some of the effects of ion trapping in a large-amplitude ion wave are a frequency shift and a reduction of the ion Landau damping, whose influences on SBBS have been addressed in part in Refs. 1, 2 and 6. Reference 6 also analyzes how inhomogeneity in the mean ion drift parallel or anti-parallel to the SBS backscatter and the nonlinear frequency shift due to ion trapping together affect the overall SBBS gain (auto-resonance and anti-auto-resonance effects). Here we also report simulation results in a nonlinear regime where there is ion trapping including a linear gradient in the mean ion drift.

For SBBS in a high gain limit with $ZT_e/T_i >> 1$ and including the effects of ion-ion collisions or inhomogeneity, we find that ion trapping and secondary ion wave instability are robust saturation mechanisms.

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

[1]B.I. Cohen, B.F. Lasinski, *et al.,* Phys. Plasmas **4**, 956 (1997).
[2]B.I. Cohen, L. Divol, A.B. Langdon, and E.A. Williams, Phys. Plasmas, in press.
[3]P.W. Rambo, S.C. Wilks, and W.L. Kruer, Phys. Rev. Lett. **79**, 83 (1997).
[4]M.E. Jones, *et al.,* J. Comp. Phys. **123**, 169, (1996).
[5]W. M. Manheimer, M. Lampe, and G. Joyce, J. Comp. Phys. **138**, 563 (1997).
[6]E.A. Williams, B.I. Cohen, *et al.* , Phys. Plasmas **11**, 231 (2004).

35th Annual Anomalous Absorption Conference
Fajardo, Puerto Rico
June 26 – July 1, 2005

MP3

Stimulated Raman Scattering in One Dimension

B.J. Winjum, F.S. Tsung, W.B. Mori,[1] and A.B. Langdon[2]
[1] *University of California, Los Angeles*
[2] *Lawrence Livermore National Laboratory*

Using the full-PIC code OSIRIS, we have studied stimulated Raman scattering (SRS) over a wide range of parameters relevant to NIF. In previous one-dimensional simulation studies using reduced PIC, Vlasov, or full PIC models, the modification of the electron distribution function and/or electron trapping effects are believed to play the dominant role in explaining the recurring behavior of SRS reflectivity. These past studies have proposed different mechanisms for the recurrence and saturation of SRS. Vu et al., proposed that a nonlinear frequency shift due to the trapped particles detunes the instability, Brunner and Valeo argue that the trapped-particle instability is the dominant saturation mechanism, while L. Yin et al., claim that electron beam acoustic modes are important. We will discuss the role played by each of these effects in OSIRIS simulations, as well as the importance of plasma wave convection on the recurrence of SRS reflectivity. We will also discuss the modifications to the electron plasma wave dispersion relation, and phase space vortices which coincide with the appearance of SRS and distribution function flattening.

Work supported by the DOE grant DE-FG02-03NA00065

35th Annual Anomalous Absorption Conference
Fajardo, Puerto Rico
June 26 – July 1, 2005

MP4

Stimulated Raman Scattering in Two Dimensions and Density Gradients

B.J. Winjum, F.S. Tsung, W.B. Mori
[1] *University of California, Los Angeles*

We have extended our one-dimensional stimulated Raman scattering (SRS) studies (partner poster by B. Winjum et al. presented earlier) to two-dimensions. In addition, we have also begun to investigate the role of density gradients. When the laser intensity is near-threshold for SRS and the laser is focused to a finite width, we find in two-dimensional studies that the physics remains rather one-dimensional behavior. On the other hand, for plane-wave lasers as well as for higher-laser-intensities, the physics becomes multi-dimensional. Side-scattering and electron trapping by forward SRS will be discussed. We will also discuss SRS in density gradients and the evolution of plasma wave characteristics as plasmons convect along the gradient.

Work supported by the DOE grant DE-FG02-03NA00065

Smoothing Induced by Stimulated Brillouin Scattering in an Inhomogeneous Plasma

P. Loiseau[1], M. Casanova, S. Hüller*, O. Morice, D. Pesme*, D. Teychenné

CEA/DIF, BP 12, 91680 Bruyères-Le-Châtel, France
* *Centre de Physique Théorique, École Polytechnique 91128 Palaiseau cedex, France*
[1] *pascal.loiseau@cea.fr*

In the context of the future laser fusion facilities (LMJ and NIF), the laser targets designed to reach ignition involve the propagation of many beams into underdense and hot plasmas. Ignition designs are sensitive to three-wave parametric instabilities, such as stimulated Brillouin scattering (SBS). Despite numerous experiments and theoretical studies identifying various regimes for SBS, it still remains difficult to predict the SBS behaviour in LMJ or NIF plasmas, because it evolves on long temporal (hundreds of ps) and spatial (mm size) scales. For this reason, such plasmas cannot be considered as quasi-homogeneous and stationary, and, therefore, the time-dependent inhomogeneity has to be properly taken into account.

The spatial dependence of macroscopic variables such as density, temperature and velocity leads to a local modification of phase matching conditions together with a spatial dependence of the coupling coefficients, therefore limiting the interaction region. In addition, under certain circumstances, the plasma inhomogeneity is able to transform spatial amplification into absolute instability. There have been many more studies [1] after Rosenbluth's [2] celebrated paper. However, apart from the Fuchs [3] study, the nonlinear behaviour has always been neglected, and the interpretation of the experimental results was based mainly on the time-dependent evolution of SBS in 1D flowing plasma [4] in the convective instability regime.

By means of our multi-dimensional and parallel code HERA, we carried out two-dimensional simulations of SBS of an incoherent incident wave in a time-dependent inhomogeneous plasma. SBS is described by three coupled wave equations in which the macroscopic plasma parameters are self-consistently obtained from the equations describing the global momentum and mass conservations. In the weak damping limit, both incident and backscattered electromagnetic waves exhibit an additional spatial incoherence, which can be seen in particular by a modification of the hot spot spatial profiles. This new optical smoothing effect takes place only when pump depletion and plasma inhomogeneity are both taken into account. It can therefore be conjectured that the temporally varying inhomogeneity is one of the key processes to the understanding of the nonlinear SBS evolution.

[1] G. Picard and T. W. Johnston, Phys. Rev. Lett. 51, 574, 1983. T. W. Johnston *et al.*, Plasma Phys. Contr. Fusion 27, 473, 1985.

[2] M. R. Rosenbluth, Phys. Rev. Lett. 29, 565, 1972.

[3] V. Fuchs and G. Beaudry, Phys. Fluids 21, 280, 1978.

[4] R. P. Drake and E. A. Williams, Phys. Rev. Lett. 67, 2477, 1991.

Absolutely Calibrated Spectra in the 150 nm to 250 nm Range from NIKE KrF Laser Produced Plasmas

U. Feldman[1], J. F. Seely[2], G. E. Holland[3], J. L. Weaver[3], C.M., Brown[3], A. N. Mostovych[3], S. P. Obenschain[3], A. J. Schmitt[3], R. Lehmberg[3], B. Kjornarattanawanich[4], and C. A. Back[5]

[1] ARTEP Inc., Ellicott City MD 21042
[2] Naval Research Laboratory, Washington DC 20375
[3]SFA Inc., 9315 Largo Drive, West Suite 200, Largo MD 20774
[4] Universities Space Research Associates, Columbia MD 21044
[5] Lawrence Livermore National Laboratory, Livermore CA 94550

Abstract

High resolution vacuum ultraviolet (VUV) spectra were recorded from plasmas generated by the NIKE KrF laser for the purpose of observing emission from the two-plasmon decay instability (TPDI) at 2/3 the NIKE wavelength (165 nm). The targets were irradiated by up to 43 overlapping beams with intensity up to $\approx 10^{14}$ W/cm^2 and with beam smoothing by induced spatial incoherence (ISI). The targets consisted of planar foils of CH, BN, Al, Si, S, Ti, Pd, and Au. Titanium-doped silica aerogels in pyrex cylinders were also irradiated. Spectra of the target elements were observed from charge states ranging from the neutral atoms to 5 times ionized. The spectrometer was absolutely calibrated using synchrotron radiation, and absolute VUV plasma emission intensities were determined. Emission from the TPDI at 165 nm wavelength was not observed from any of the irradiated targets. An upper bound on the possible TPDI emission was less than 4×10^{-8} the incident NIKE laser energy. The NIKE laser radiation backscattered from the silica aerogel targets at 248 nm was typically 6×10^{-6} the incident NIKE laser energy, and the spectral broadening corresponded to the 1 THz bandwidth of the ISI smoothing. The spectra from the moderately charged plasma ions (up to 5 times ionized), spectral line widths, absolute continuum emission level, and slope of the continuum were consistent with plasma temperatures in the 100 eV to 300 eV range. Further studies of TPDI and the backscattered 248 nm radiation are planned with a 300 times more sensitive spectrometer with time-resolution and high spatial and spectral resolution.

Degenerate four-wave mixing in vacuum

Herbert Brown [a], Qiguang Yang [a, d], JaeTae Seo [a], Keith Baker [a], Andrei Afanasev [b], Bagher Tabibi [a], SeongMin Ma [a], SungSoo Jung [c], Huitian Wang [d]

[a] *Department of Physics, Hampton University, Hampton, VA 23668*
[b] *Jefferson Lab., Newport News, VA 23602*
[c] *Korea Research Institute of Standards and Science, Daejeon, South Korea, 305-600*
[d] *National Laboratory of Solid State Microstructures and Department of Physics, Nanjing University, Nanjing, 210093, China*

Modifications to the Maxwell's equations are needed to account for the quantum electrodynamics (QED) predicted in photon-photon interaction, at very strong electromagnetic fields in vacuum. Vacuum behaves like a normal nonlinear optical material when subjected to nonlinear interaction. Birefringence of the vacuum in the presence of either a strong external DC field or a strong laser pumping has been investigated for many years. Due to the symmetry of the interaction, photon-photon scattering gives rise to second-harmonic generation in a DC magnetic field. Also proven theoretically is self-focusing and bright spatial soliton of a laser pulse in vacuum. Recently, four-wave mixing (FWM) has been proposed for detection of QED vacuum nonlinearities.

Many nonlinear optical phenomena in vacuum have been predicted, they greatly differ from their counterparts in normal nonlinear optical materials. In a normal nonlinear optical material the intrinsic property of the material is the optical nonlinearity. This optical nonlinearity is independent of the applied laser beams. However, the effective third-order nonlinear susceptibilities of vacuum are determined completely by the properties of the interacting light beams as well as the geometric configuration of these beams.

Forward degenerate four-wave mixing (F-DFWM) in vacuum is the main topic of discussion in this work. It will be shown that efficient forward degenerate four-wave mixing may appear at a large cross angle due to the increase of the effective third-order nonlinear optical susceptibility of vacuum with the cross angle. This is contrary to what occurs in normal nonlinear optical materials. This unique phenomenon may be used to distinguish the vacuum forward degenerate four-wave mixing signal from the comparable background signal from the surplus gas atoms in the vacuum chamber in experiment and therefore improve the experimental sensitivity.

Emergence of space charge effects in the linear stage of the Weibel like current filamentation instability

M. Tzoufras, F.S. Tsung, J.W. Tonge, W.B.Mori
University of California at Los Angeles

C.Ren
University of Rochester

L.O.Silva and M.Fiore
IST Portugal

We examine how electrostatic modes couple to the current filamentation instability. When drifting electron beams, that are unstable to electromagnetic modes with wave vectors perpendicular to the drift, have different transverse temperatures they tend to pinch to different degrees in the magnetic field of the unstable mode. This leads to a charge imbalance, and thus causes the heavy ion background to respond. This physical effect significantly retards the growth of the instability. As modes with high wave numbers experience more of this type of electrostatic coupling, the spectrum of the instability changes, leading to maximum growth for wavelengths longer than what theory for purely electromagnetic modes predicts. It is because of this coupling that the so-called electromagnetic mode allows density filaments to emerge. Formulas that include electrostatic coupling to the electromagnetic mode are presented, and simple solutions that illustrate the physical picture are obtained in the weak anisotropy limit. We use PIC simulations to verify our results.

Work supported by DOE.

35th[d] Annual Anomalous Absorption Conference
Fajardo, Puerto Rico
June 26th - July 1st, 2005

MP9

Wavelets, Curvelets and Multirtesolution Analysis Techniques Applied to ICF and Z Pinch Research*

Bedros Afeyan,[1] K. Won,[1] J.L. Starck,[2] M. Cuneo,[3] G. Bennett,[3] R. Stephens[4] and D. Montgomery[5]

[1]Polymath Research Inc., Pleasanton, CA [2]CEA, Saclay, FR,
[3]SNL, [4]General Atomics, [5]LANL

We will show, through a number of diverse applications, how multiresolution analysis (MRA) can have a strong impact in inertial confinement fusion (ICF) and Z pinch research. We will start with the characterization of ICF target surface roughness and imperfections using wavelets and curvelets on the sphere contrasting their advantages over spherical harmonics at finer scales of the MRA. We will then show Be and DT ICE layer deposition dynamics characterization by denoising a sequence of time lapse photographic images and identifying the non-smooth, noncircular elements in the perimeters of those layers. We will then consider rad-hydro simulation data of ICF implosions in order to contrast the wavelet decomposition and information compression characteristics of instability free and igniting targets vs duds with strong Rayleigh-Taylor nonlinear growth. Our choice will be to use (1+1) D wavelet decompositions in these highly anisotropic (r, θ) data sets.

In Z pinches, we will focus on three separate applications: (1) The characterization of the radiation asymmetry of double Z pinch Hohlraums from noisy X ray backlighting images using curvelets and undecimated wavelet transforms. (2) In nested wire array implosions, denoising X ray backlighting images so that the individual wire MHD instabilities can be identified and contrasted with collective wire array MHD modes. (3) Characterization of Astrophysical radiation jets and K-H rolls emulated in the laboratory using Z pinches.

The unifying themes throughout these applications, will be denoising and pattern detection using optimal phase space tiling techniques such as wavelets and curvelets for signals (1D), images (2D) and volume data such as spherical surface imperfections (3D). Whether it is spectroscopy or imaging in noisy environments, ICF research can benefit greatly by the adoption of these techniques where proper statistical analysis plays a key role.

*This work was funded in part by Sandia National Laboratories and General Atomics.

Prefer Poster Presentation.

Small-Amplitude Theory of Interaction of Rippled Shock and Rarefaction Waves in Laser-Driven Targets

A. L. Velikovich[a] and N. Metzler[b]

[a]*Plasma Physics Division, Naval Research Laboratory, Washington, D.C. 20375*
[b]*Science Applications International Corporation, McLean, VA 22150.*
Permanent address: NRCN, P. O. Box 9001, Beer Sheva, Israel

Small-amplitude perturbations produced in laser-driven targets by surface roughness and irradiation non-uniformity could be decomposed into Fourier modes and studied theoretically and computationally one mode at a time. To validate theory and simulations, experiments are often done with single-mode perturbations imposed at the front or rear surface of the target, or at an imbedded interface separating high and low density layers in the targets. Such perturbations give rise to single-mode rippled shock and rarefaction waves, ablative Richtmyer-Meshkov (RM) growth at the ablation front and classical RM growth at the material interface. Each of these phenomena is well described by the existing small-amplitude theory.

In the small-amplitude approximation, one can neglect the interaction between uncorrelated rippled waves of different wavelengths. The waves in the target, however, often are correlated [1], and their interaction thereby cannot be neglected. For example: (1) A rippled rarefaction wave is produced when a rippled shock wave from the rippled ablation front breaks out at the rear surface of a target. It is initiated differently from the case when only the rear surface of the target is rippled [2], and the fluid ahead of the reflected rarefaction wave is unperturbed; here, the rarefaction wave propagates into a coherent sonic/entropy wave field left behind the incident rippled shock wave. (2) A rippled shock wave reflected from a rippled material interface breaks out at a non-perturbed ablation front, triggers an ablative RM instability growth there, and launches a rippled rarefaction wave, which also propagates into a perturbed wave field. (3) A rippled shock wave hits a material interface and triggers a classical RM growth there.

Understanding of these coherent phenomena is important for detailed analysis of the experiments on early-time perturbation growth in laser targets. We report a small-amplitude theory of coherent interactions between rippled shock, rarefaction, sonic and entropy waves, compare its results to numerical simulations and apply them to the analysis of experiments done on the Nike laser at NRL with planar foam-plastic targets rippled at the material interface.

Work supported by the U. S. Department of Energy and performed at the Naval Research Laboratory.

[1] N. Metzler *et al.*, Phys. Plasmas **10**, 1897 (2003).
[2] A. L. Velikovich *et al.*, Phys. Plasmas **8**, 592 (2001); Y. Aglitskiy *et al.*, Phys. Rev. Lett. **87**, 265002 (2001).

Poster session preferred.

35th[d] Anomalous Absorption Conference
Fajardo, Puerto Rico
June 26-July1, 2005

MP11

High Dynamic Range Imprint Measurements on Nike Laser

Max Karasik, Y. Aglitskiy[1], V. Serlin, J. W. Bates,

Plasma Physics Division, Naval Research Laboratory, Washington, DC 20375

[1]Science Applications International Corporation, McLean, VA, 22150

Naval Research Laboratory, Washington, DC 20375

Accurate quantitative simulations of hydrodynamic instability seeded by laser non-uniformity (laser imprint) are important in predicting performance of direct-drive ICF targets. In order to benchmark such simulations, we are carrying out experiments on imprint on the Nike KrF laser with induced spatial incoherence (ISI) smoothing. Most of the imprint occurs during the initial low-intensity ("foot") part of the pulse, which is necessary to compress the target to achieve high gain. In the experiments, the amount of imprint is controlled by changing the uniformity the foot of the pulse. Measurements of the resulting Raleigh-Taylor (RT) amplified areal mass non-uniformity are made by face-on x-ray radiography using Bragg reflection from a curved crystal coupled to an x-ray streak camera. The streak camera was recently retrofitted with a new high sensitivity CCD camera. The sensitivity of the CCD has enabled it to be fiberoptically coupled directly to the streak camera output, without an image intensifier and lens coupling. This gave an overall increased spatial resolution as well as lower noise. Because of the strong short wavelength component of RT amplified imprint, the increased resolution and lower noise resulted much lower noise floor in the measurement. The increased dynamic range allows for better comparison with the simulations. We will present the experimental results and comparisons with 2D simulations using FAST hydrocode.

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

Hydrodynamic stability of direct-drive high-gain IFE targets

J.W. Bates,[a] A.J. Schmitt,[a] D.E. Fyfe,[b] and J.H. Gardner,[b]
[a]*Laser Plasma Branch, Plasma Physics Division*
[b]*Laboratory for Computational Physics and Fluid Dynamics*
U.S. Naval Research Laboratory, Washington, DC 20375

35th Anomalous Absorption Conference
Fajardo, Puerto Rico
June 26 - July 1, 2005

Abstract

Success with direct-drive high-gain targets for inertial fusion energy (IFE) depends fundamentally on understanding (and controlling) the hydrodynamic instabilities that develop during the implosion process. A central task in this endeavor is to determine the tolerances for target surface finishes and optically-smoothed laser drive. Because available experimental facilities are unable to directly assess the effect that nonuniformities from such sources has on ignition and yield, numerical simulations coupled with analytical modeling are extremely important. In this poster presentation, we discuss the status of single-mode stability calculations performed with the FAST radiation hydrocode on NRL's high-gain target designs, and compare our results with ablative Richtmyer-Meshkov and Rayleigh-Taylor theories. The two-dimensional spherical simulations predict that the performance degrades significantly from the one-dimensional "clean" case, but may be improved through the use of a spike pre-pulse or high-Z layer.

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

A new algorithm for solving non-LTE atomic populations in hot plasmas

Marcel Klapisch & Michel Busquet
ARTEP, inc.[#]
Ellicott City, MD 21042

Most ICF plasmas are not in Local Thermodynamic Equilibrium (LTE) because of gradients of temperature and radiation losses. Therefore, the Saha-Boltzman statistical population "laws" do not hold. Consequently, for the computation of opacities and equations of state, rate equations have to be set and solved for the level populations of atomic ions. These can be fine structure levels, configurations, or superconfigurations, depending on the complexity of the spectra. The rate equations to be solved often involve tens of thousands of levels.

We present here an algorithm which is more physical than the commonly used biconjugate gradient[1]. The populations are factorized into total ion $\mathrm{N}_z = \sum_{i\in z} N_i$ and reduced level $n_i = N_i/\mathrm{N}_z$.

This yields a double linearized iterative scheme, alternating between the total ion populations, and the reduced ones. The matrices to be inverted are the one within each ion. The condition of these is much better than that of the whole matrix, so the algorithm is more reliable. Total ionization and recombination rates are iteratively refined, so it is possible to quickly converge on average charge Z*. Results on Xe and comparison with other methods will be shown.

Work supported by the USDOE under a contract with Naval Research Laboratory, Laser Plasma Branch.

1 W. H. Press, B. P. Flannery, S. A. Teukolsky et al., *Numerical Recipes in Fortran 77*, 2nd ed. (Cambridge University Press, Cambridge, UK, 1996).

[#] Contractor to the Naval Research Laboratory, Washington, DC 20375.

MP14

STIMULATED RAMAN SCATTERING FROM HOT, UNDERDENSE PLASMAS*

Carmen G. Constantin, H.A. Baldis
University of California at Davis
Davis, CA, 95616

Marilyn B. Schneider, D.E. Hinkel, A.B. Langdon
Lawrence Livermore National Laboratory,
Livermore, CA 94550

W. Seka, R. Bahr
Laboratory for Laser Energetics
Rochester, NY

Sylvie Depierreux
Departement de Conception et de Realisation des Experimentations, CEA-DIF
France

Stimulated Raman scattering (SRS) instability has been experimentally investigated in small-scale halfraums irradiated by intense laser pulses at 10 TW power. The driver energy was delivered by the OMEGA laser (LLE, Rochester) in 1 ns pulses, and deposited in a hot, under-dense Au plasma. The laser energy deposition shifts at later times outside the laser entrance hole (LEH) due to a rapid plasma fill of the hohlraum. Most of the SRS light is scattered from this region and detected with time and spectral resolution. The high temperature of the scattering volume is reflected in the SRS spectrum that extends beyond two times the laser wavelength, due to the Bohm-Gross shift. Information about the plasma parameters inferred from the SRS spectra will be discussed.

**Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract No. W-7405-ENG-48 and grant number DE-FG52-2005NA26017 (NLUF)

Modeling parametric scattering instabilities in large-scale expanding plasmas

P. E. Masson-Laborde[1,2], S. Hüller[1], F. Detering[1], D. Pesme[1], M. Casanova[2], P. Loiseau[2], O. Morice[2]

[1]Centre de Physique Théorique, Ecole Polytechnique, CNRS UMR 7644, Palaiseau France,
[2]CEA-DIF/DCSA, Bruyères-le-Châtel, France

In the context of laser fusion the control of parametric instabilities is a primordial problem. Reliable modeling of parametric instabilities in fusion-relevant plasmas requires a high spatial and temporal resolution to properly describe the involved plasma waves. However, to perform such simulations of laser-plasma interaction on the scale of fusion-relevant plasmas is still beyond computational capacities.

To describe scattering instabilities like Stimulated Briilouin Scattering (SBS) and Stimulated Raman Scattering (SRS) with the goal of predictive modeling in an expanding mm-scale plasma, we have developed a numerical code which makes use of the decomposition of spatial scales : while one can use a conventional hydrodynamics code for the long-scale length plasma expansion, the short-wavelength plasma waves excited by the scattering instabilities are described by paraxial envelope equations. In our model the momentum transfer between both long- and short-scale length components is taken into account consistently. We consider plasma wave nonlinearities by solving additional equations for higher harmonics. To describe the incident laser field and the scattered light field we use the paraxial approximation. We have benchmarked our decomposition code "Harmony1D/2D" in both one (1D) and two dimensions (2D) for the case of SBS against a "complete" code in which no spatial decomposition, neither in hydrodynamics nor in the electromagnetic field, is done The comparison for an expanding inhomogeneous plasma profile shows very good agreement between both type of codes. The results underline the importance of higher harmonics of the SBS-driven ion sound waves, and the necessity of including them in the decomposition code. We have also performed a comparison with a particle-in-cell code which also shows good agreement in a limited parameter regime. Besides the fact that decomposition codes allow to simulate large-scale plasma volumes and are computationally very efficient, they also permit to include further mechanisms by additional terms derived from phenomenological models, such as for kinetic effects. Since kinetics effects are associated with subharmonic generation, we study this decay by introducing subharmonic components in the decomposition model and compare the evolution with the results of a full hydrodynamic description.

35th Annual Anomalous Absorption Conference
Fajardo, Puerto Rico, June 27-July 1, 2005

Revisiting stimulated Brillouin scattering in inhomogeneous plasmas

M. Casanova, P. Loiseau, O. Morice, D. Teychenné
CEA-DIF, BP 12, 91680 Bruyères-le-Châtel, FRANCE
S. Hüller, D. Pesme
Centre de Physique Théorique, Ecole Polytechnique,
91128 Palaiseau Cedex, FRANCE

Modeling Stimulated Brillouin Scattering (SBS) is very demanding computationally in multidimensional mm-size plasmas because of the disparity of spatial scales associated to the hydrodynamic motion and to the scattering of the incident laser wave on the ion acoustic wave (IAW). In order to account for the nonlinear processes developing in large-scale plasmas under the influence of smoothed laser beams, we have derived equations based upon the decomposition (1) of the hydrodynamics variables in long and short-wavelength components and (2) of the light in incident and scattered components. These equations make it possible to describe the self-consistent coupling between the plasma hydrodynamics, SBS, and the generation of harmonics and sub-harmonics of the excited IAW (see the contributions of P. Loiseau and P.-E. Masson-Laborde at this conference).

In order to understand the 2D numerical results showing plasma induced smoothing of the backscattered wave, we returned to a 1D description in which we retained the inhomogeneity of the density and flow profiles. Namely, we considered the decay process described by the following set of equations

$$\begin{cases} \dfrac{\partial a_0}{\partial t} + \dfrac{\partial a_0}{\partial x} = -\gamma_0(x)\, a_1 a_s \\ \dfrac{\partial a_1}{\partial t} - \dfrac{\partial a_1}{\partial x} = \gamma_0(x)\, a_0 a_s^* \\ \dfrac{\partial a_s}{\partial t} + \varepsilon \dfrac{\partial a_s}{\partial x} + i M(x)\, a_s = \gamma_0(x)\, a_0 a_1^* \end{cases}$$

where the complex envelope amplitudes a_0, a_1 and a_s respectively stand for the pump wave, the backscattered wave and the IAW. The density inhomogeneity is taken into account in the coupling constant $\gamma_0(x)$, and the flow inhomogeneity is described by the term $M(x)$ representing the corresponding Doppler shift. Firstly, neglecting pump depletion, we reconsidered the linear problem which had been studied thirty years ago.[1,2] We identified new regimes. Secondly, we considered the nonlinear problem and we showed the consequences for multidimensional SBS simulations.

1 M. N. Rosenbluth, Phys. Rev. Lett. **29**, 565 (1972)
2 T. W. Johnston, G. Picard, J. P. Matte, V. Fuchs, M. Shoucri, Plasma Phys. **27**, 473 (1985)

Tuesday, June 28th, 2005

9:00 - 10:40 AM	Oral Session: Hydrodynamics Session Chair: V. N. Goncharov
10:40 - 11:00 AM	Coffee Break
11:00 - 12:40 PM	Oral Session: Direct Drive/Implosions Session Chair: S. Zalesak
7:30 - 8:30 PM	Evening Invited Talk Lessons from Ionospheric Excitation Experiments at Arecibo for Laser-Plasma Instability Studies D. DuBois
8:30 - 11:00 PM	Evening Poster Session

Oral Session 3

Hydrodynamics

Session Chair: V. N. Goncharov

9:00 - 10:40 AM

Distribution of sizes in the mixed state generated by Rayleigh-Taylor instability

G. Hazak [(1),(2)] , Y. Elbaz [(2)] , J. H. Gardner [(3)] , A. L. Velikovich [(4)]
and A.J. Schmitt [(4)]

An analysis, based on simulations and experiments, of the partially mixed state generated by the Rayleigh-Taylor instability at the interface between two fluids will be presented. The function which characterizes the distribution of the sizes of fluid volumes in the partially mixed state will be analyzed.
It will be shown that this function depends on a single variable which is a dimensionless combination of the physical constants involved as well as the size, time and distance from the original interface.

(1) *Berkeley Research Associates Inc., Springfield VA 22150*
(2) *Permanent address: Physics Department, Nuclear Research Center, Negev, Beer Sheva, Israel.*
(3) *LCP&FD Naval Research Laboratory, Washington DC.*
(4) *Plasma Physics Division, Naval Research Laboratory, Washington DC.*

Critical Path to Impact Fusion Ignition—Suppression of the Rayleigh-Taylor Instability

H. Azechi, M. Murakami, H. Nagatomo, T. Sakaiya, S. Fujioka, H. Shiraga, M. Nakai, K. Shigemori, A. Sunahara, *Institute of Laser Engineering, Osaka University, Japan*
S. Obenschain, M. Karasik, J. Gardner, J. Bates, D. Colombant, J. Weaver, Y. Aglitskiy[1],
Naval Research Laboratory, Washington DC, [1]*SAIC*

Recently, there have been a number of schemes for suppression of the Rayleigh-Taylor (RT) instability. The sufficient suppression of the RT instability not only increases compressed density, but it may also revive an old ignition idea: High velocity implosion with 1000 km/s may configure a hot-spark without a surrounding cold main fuel and thereby ignite at a very low laser energy of 30-100 kJ. This idea was rejected by two major criticisms. One, the RT instability limits the maximum implosion velocity well below the required velocity. Two, there is no pathway towards high gain. The first criticism may be overcome by introducing one of the new suppression schemes. The second criticism may be solved by the impact fusion ignition (IFI) configuration [M. Murakami, Nucl. Instrum. Methods A, in press]. Figure 1 schematically illustrates the principle: a main fuel is first imploded, whereas the ignition is made by impact collision of the second partial shell with high velocity of 1000 km/s. There are several advantages in this idea. 1) This can be high-gain because a main fuel is introduced. 2) Simple because the main physics is hydrodynamics. 3) Low cost because there is no need for expensive laser pulse compressors. Our 2D hydrodynamic code PINOCO indicates that the high velocity part of the target is converted to high temperature and high density igniter surrounded by a low temperature high density main fuel. This is in sharp contrast to the conventional high temperature but low dense hot-spark.

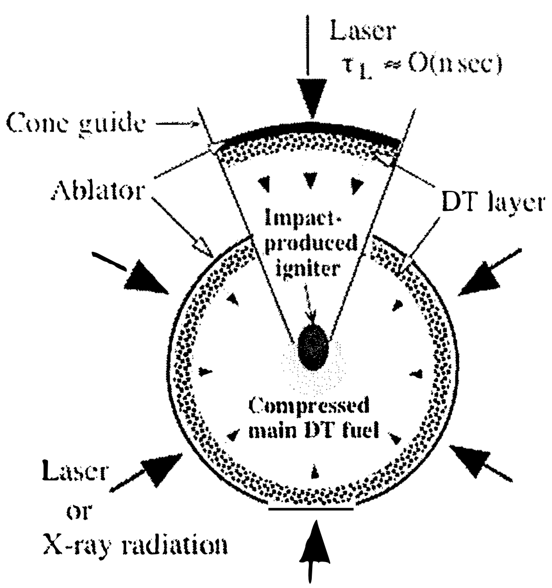


FIG. 1 Principle of impact fusion ignition

A critical path requirement of this new ignition scheme is obviously the demonstration of the super velocity. A preliminary experiment of generic polystyrene target irradiated with HIPER laser system, that combines many beams into one beam, has already demonstrated the velocity of 400 km/s. We plan to employ several RT suppression schemes in attempts to reach higher velocities using the HIPER and NIKE lasers.

TO~~3~~2

Experimental Studies of Classical Richtmyer-Meshkov and Non-Linear Rayleigh-Taylor Instabilities

Y. Aglitskiy, N. Metzler,
SAIC, McLean, VA,
A. L. Velikovich, M. Karasik, V. Serlin, A. J. Schmitt, S. Obenschain,
Plasma Physics Division, Naval Research Laboratory,
J. H. Gardner,
LCP&FD, Naval Research Laboratory.

This is a progress report on our continuing efforts to benchmark computer codes in cases that allow *ab initio* stimulations [1]. We will present the results of our hydrodynamic experiments on the KrF Nike laser at NRL and simulations that include a detailed study of the classical Richtmyer-Meshkov (RM) instability and non-linear Rayleigh-Taylor (RT) growth.

We have observed for the first time the oscillatory transient processes responsible for the evolution of perturbation growth triggered by the classical RM instability at a shocked material interface in a plastic-foam laser target to the RT growth when the target starts to accelerate. The observed evolution of perturbations is in agreement with our theory and simulations. Our experimental study now covers all the relevant processes of RT seeding caused by the laser target imperfections, which can be located at its outer or inner [1] surface, or at embedded interface.

First results of our planned comprehensive experimental studies as well as 2d simulations of ablative RT growth in planar plastic targets will be presented.

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

[1] Y. Aglitskiy, A. L. Velikovich, M. Karasik, V. Serlin, C. J. Pawley, A. J. Schmitt, S. P. Obenschain, A. N. Mostovych, J. H. Gardner, N. Metzler, Phys. Plasmas **9**, 2264-2276 (2002).

Prefer Oral Session

Nonlinear Rayleigh–Taylor Growth Measurements on OMEGA

V. A. Smalyuk, O. Sadot, J. A. Delettrez, D. D. Meyerhofer, S. P. Regan, and T. C. Sangster

Laboratory for Laser Energetics, University of Rochester
250 East River Road, Rochester, NY 14623

The nonlinear growth of 3-D broadband nonuniformities was measured near saturation levels using x-ray radiography in planar foils accelerated by the OMEGA laser. The initial target modulations were seeded by laser nonuniformities and later amplified by the Rayleigh–Taylor instability. The nonlinear saturation velocities are measured in Fourier space and are found to be in excellent agreement with Haan predictions [Phys. Rev. A **39**, 5812 (1989)]. The measured growth of long-wavelength modes is consistent with enhanced, nonlinear, long-wavelength generation in ablatively driven targets. In real space, bubble merger is quantified by the evolution of the bubble size, amplitude, and velocity distributions.

This work was supported by U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460, the University of Rochester, and New York State Energy Research and Development Authority.

Prefer oral session

35th Anomalous Absorption Conference, Puerto Rico
June 27-July 1, 2005

Bell-Plesset effects for an accelerating interface with contiguous density gradients in ignition double shells*

Peter Amendt
Lawrence Livermore National Laboratory, Livermore, CA USA 94550

Abstract

Numerical simulations of imploding ICF capsules typically have one or more classical interfaces, each representing a discontinuity in density and material properties. In proposed double-shell ignition targets [1] for the National Ignition Facility the interface between the DT fuel and the high-Z inner shell has a high Atwood number At and is characterized by contiguous density gradients on both sides. The gradients are due to thermal conduction from the fuel to the inner shell and have scalelengths on the order of a few microns within the pusher. Similar gradients are seen in simulations of Omega-class, indirectly-driven, plastic single-shells [2]. Although the effect of conduction is to reduce the Atwood number of the interface, the coalignment of the acceleration and the density gradients after deceleration onset can increase the Rayleigh-Taylor instability growth rate. This increase is due to the effectively larger Atwood number seen by a surface perturbation which samples a radial distance on the order of a wavelength across the interface. Thus, growth of long wavelength perturbations will be significantly affected by contiguous density gradients, in contrast to the standard case of a finite density-gradient interface where stabilization only occurs for the shortest wavelengths [3]:

$$\gamma_{RT} = \sqrt{\frac{At \cdot kg}{1 + At \cdot kL_\rho}}. \tag{1}$$

An extension of a Plesset-type treatment to include contiguous density gradients in a compressible, spherical geometry is presented. The resulting governing equation for linear perturbation growth is fully consistent with adopted power-law density profiles in the fuel and pusher regions and at arbitrary distances from the interface. The role of contiguous density gradients on Bell-Plesset growth and Rayleigh-Taylor instability is assessed. In the planar limit the effect of contiguous density gradients on classical Rayleigh-Taylor growth is found to follow:

$$\gamma_{RT} = \sqrt{At \cdot kg \cdot \left(\frac{2k|L_\rho|}{\sqrt{1 + 4k^2 L_\rho^2} \pm At} \right)}, \tag{2}$$

where $\pm L_\rho < 0$.

[1] P. Amendt, J.D. Colvin, R.E. Tipton *et al.*, Phys. Plasmas **9**, 2221 (2002).
[2] P. Amendt., O.L. Landen, and R.E. Turner, Phys. Rev. Lett. **81**, 5153 (2000).
[3] R. Betti, V.N. Goncharov, R.L. McCrory and C.P. Verdon, Phys. Plasmas **5**, 1446 (1998).

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

Oral Session 4

Direct Drive/Implosions

Session Chair: S. Zalesak

11:00 - 12:40 PM

High Performance Direct-Drive Implosions Using Cryogenic D_2 Fuel

T. C. Sangster, R. S. Craxton, J. A. Delettrez, D. H. Edgell, R. Epstein, V. Yu. Glebov, V. N. Goncharov, D. R. Harding, D. Jacobs-Perkins, J. P. Knauer, S. J. Loucks, F. J. Marshall, R. L. McCrory, P. W. McKenty, D. D. Meyerhofer, P. B. Radha, S. P. Regan, W. Seka, V. A. Smalyuk, J. M Soures, and C. Stoeckl
Laboratory for Laser Energetics, University of Rochester
250 East River Road, Rochester, NY 14623

J. A. Frenje, C. K. Li, R. D. Petrasso, and F. H. Séguin
Plasma Science and Fusion Center, Massachusetts Institute of Technology

The validation of the "all-DT" target design [P. W. McKenty *et al.*, Phys. Plasmas **8**, 2315 (2001)] for direct-drive ignition on the National Ignition Facility (NIF) will be based on energetically scaled implosions of cryogenic D_2 and DT fuel using the OMEGA laser. Recent cryogenic D_2 implosions using low-adiabat drive pulses ($\alpha \sim 4$, where the adiabat α is the ratio of the fuel pressure at the inner ice surface to the Fermi-degenerate pressure) have achieved high neutron-averaged areal densities (~100 mg/cm^2) and burn performance consistent with the expectations of the 2-D hydrocode *DRACO* when the various sources of target and drive nonuniformity are included (e.g., ice roughness, drive symmetry, and single-beam uniformity). Ice roughness and drive symmetry are currently the limiting factors in achieving ignition-equivalent performance (the best layers to date are still a factor of 2 away from the NIF ignition requirement of 1-μm rms). This talk will present the most recent implosion performance data using D_2 fuel, discuss progress in achieving ignition-equivalent ice layers and drive uniformity, and finish with the prospects for near-term implosions using DT fuel.

This work was supported by U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC52-92SF19460, the University of Rochester, and New York State Energy Research and Development Authority.

Prefer oral session

Diagnosing Shock-Heated, Direct-Drive Plastic Targets with Spectrally Resolved X-Ray Scattering

S. P. Regan, H. Sawada, T. R. Boehly, I. V. Igumenshchev, V. N. Goncharov, T. C. Sangster, D. D. Meyerhofer, and B. Yaakobi

Laboratory for Laser Energetics, University of Rochester
250 East River Road, Rochester, NY 14623-1299

G. Gregori, D. G. Hicks, S. H. Glenzer, and O. L. Landen
Lawrence Livermore National Laboratory, Livermore, CA

Initial x-ray scattering experiments have been carried out on the OMEGA laser system to measure the electron temperature T_e and average ionization Z in shock-heated, CH targets. Plastic, planar foils (125 μm thick) were directly-driven with six overlapped beams containing distributed phase plates (SG8 DPP's) that provide uniform drive intensity within the central 0.5 mm of the 1 mm laser spot. A 1-ns square laser pulse with a peak intensity of 5×10^{14} W/cm^2 generated a 50 Mbar shock in the plastic. A 15 Mbar shock was generated with a 3-ns square laser pulse having a peak intensity of 1×10^{14} W/cm^2. The 1-D hydrocode *LILAC* predicts the shock-heated targets will have peak plasma conditions in the range $n_e \sim 1$ to 6×10^{23} cm^{-3}, $T_e \sim 10$ to 30 eV, and $Z \sim 0.5$ to 1.6. Just prior to shock breakout, the uniformly compressed region of the target was irradiated with a 9-keV, Heα, *K*-shell emission from a Zn backlighter. The x rays scattered at either 90° or 120° were dispersed with a Bragg crystal and recorded with an x-ray framing camera. The spatially averaged plasma conditions inferred from the spectral line shapes of the elastic (Rayleigh) and inelastic (Compton) components will be compared with the *LILAC* predictions.

This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC52-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

Diagnostic Potential of a Full Range Reaction History Measurement for Ignition Capsules

D. C. Wilson, P. A. Bradley, M. R. Douglas, J. M. Mack, C. S. Young (Los Alamos National Laboratory), R. A. Lerche (Lawrence Livermore National Laboratory), V. Yu. Glebov (Laboratory for Laser Energetics, U. of Rochester)

A DT burn history measurement of an ignition capsule can show pulse shaping and asymmetry errors and much more on every ignition attempt. The capsule's reaction history should be measurable using a combination of the Neutron Temporal Diagnostic (NTD) and a Gas Cerenkov Detector (GCD). Together they can cover a required dynamic range from 10^9 to 10^{21} neutrons/ns with temporal resolution of 20-30ps. An ignition capsule requires careful shaping of the radiation drive to compress the main DT and achieve ignition. A reaction history measurement shows the errors in that pulse shaping in all four of the desired radiation temperature pulses. Implosion asymmetry changes the reaction history only in its later stage, allowing errors in pulse shaping to be separated from shock timing errors. The measurement is also sensitive to errors in the central gas density. A pure tritium capsule may also be used to test shock timing errors without the high yields caused by ignition in a DT capsule.

LA-UR-05-1305

Polar-Direct-Drive Experiments on OMEGA Using Saturn targets

R. S. Craxton, F. J. Marshall, M. J. Bonino, V. Yu. Glebov, J. P. Knauer,
S. G. Noyes, W. Seka, and V.A. Smalyuk

Laboratory for Laser Energetics, University of Rochester
250 East River Road, Rochester, NY 14623-1299

Polar direct drive (PDD)[1] with Saturn targets[2] is a promising approach to ignition on the NIF using just the baseline indirect-drive ports with the beams repointed toward the target equator. The Saturn target (which adds a low-*Z* ring around the capsule) allows laser rays near the capsule equator to be refracted in the expanding ring plasma to follow the imploding critical surface and improve the time-dependent uniformity.

Three series of PDD experiments using Saturn targets have been carried out on OMEGA using 40 of the 60 beams to irradiate standard deuterium-filled plastic-shell capsules. The equatorial rings of beams are omitted, except that some of these beams are used for framed x-ray backlighting. These experiments show that the drive uniformity of Saturn targets can be accurately modeled and tuned to provide nearly symmetric implosions. In particular:

1. The greater-than-predicted drive on the capsule equator reported in the first Saturn experiments[3] has now been resolved by the inclusion of a multigroup, viewfactor-like radiation model in the two-dimensional code *SAGE*.
2. Saturn targets have been tuned by adjusting the beam pointings to produce prolate, approximately spherical, and oblate cores with the most spherical core correlated with the highest yield.
3. Different ring diameters and capsule mounting schemes (three "spokes" rather than eight spider threads) have been used.
4. The best target experiments have resulted in neutron yields ~75% of the yield from 60-beam, symmetrically irradiated targets with the same laser energy.

This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC52-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

1. S. Skupsky *et al.*, Phys. Plasmas **11**, 2763 (2004).
2. R. S. Craxton and D. W. Jacobs-Perkins, Phys. Rev. Lett. **94**, 095002 (2005).
3. R. S. Craxton *et al.*, "Polar-Direct Drive—Proof-of-Principle Experiments on OMEGA and Prospects for Ignition on the NIF," to be published in Physics of Plasmas.

Prefer oral presentation

TO10

Numerical Investigation of X-Ray Core Images from OMEGA Implosions Driven with Controlled Polar Illumination

R. Epstein, T. J. B. Collins, R.S. Craxton, J.A. Delettrez, I. V. Igumenshchev, F. J. Marshall, J. A. Marozas, P. W. McKenty, P. B. Radha, S. Skupsky, and V. A. Smalyuk
Laboratory for Laser Energetics, University of Rochester
250 East River Road, Rochester, NY 14623-1299

Time-resolved x-ray images from asymmetrically-driven implosion experiments on OMEGA reveal imploding cores with strong low-order asymmetries due to nonuniform convergence. Time-dependent x-ray images from 2-D *DRACO* simulations, post-processed with the atomic-physics/radiation-transport code Spect3D, reproduce this behavior in a series of simulations correlating the image asymmetry with known irradiation nonuniformity resulting from beam-energy adjustments and pointing, target centering, and the effects of the pointing adjustments made for polar-direct-drive (PDD) experiments. We survey recent experiments using low-order illumination asymmetry, including the case of the recent OMEGA PDD implosion experiment. Simulated and observed images are found to have similar size and asymmetry, according to quantitative analysis as well as empirical comparison. These simulations correlate improvements in beam-to-beam power balance, beam pointing, and target positioning with improved image symmetry.

This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC52-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

Prefer oral presentation

Evening Invited Talk 2

D. DuBois

Lessons from Ionospheric Excitation Experiments at Arecibo for Laser-Plasma Instability Studies

7:30 - 8:30 PM

Lessons from Ionospheric Excitation experiments at Arecibo for Laser-Plasma Instability studies

Don DuBois, Los Alamos National Laboratory*

Since the early 1970s experiments have been carried out at the Arecibo Observatory in Puerto Rico in which parametric instability (e.g.decay of an electromagnetic wave into a Langmuir wave (LW) and ion acoustic wave) is excited near the reflection altitude of a powerful HF wave in the ionosphere [1]. (At the first Anomalous absorption Conference at Princeton in 1973 these experiments had equal billing with laser-plasma interactions.) The density fluctuation frequency spectrum of the excited "Langmuir turbulence" is measured at a single fluctuation wave vector using the Arecibo radar in a Thomson scatter mode (backscatter). By the late 1990's such spectra could be obtained [2] with unprecedented altitude resolution exposing different nonlinear regimes. Detailed agreement was obtained [3] with earlier predictions [4] of nonlinear reduced modeling involving the saturation effects of the Langmuir decay instability (LDI) and concomitant Langmuir cavitation, nucleation, and collapse. Subsequent PIC simulation studies [5,6] have shown that, for parametric instabilities involving primary daughter LWs with low values of $k\lambda_D$, (i.e. low Landau damping as was the case for the above experiments), the saturation proceeds via the LDI but for higher values of $k\lambda_D$ (higher Landau damping) saturation involved electron trapping and resulting frequency detuning. Recent single hot spot experiments at the Trident laser [7] have seen this transition between saturation mechanisms in the Thomson scatter spectrum resulting from backward stimulated Raman scattering (BSRS), in qualitative agreement with PIC simulation results. BSRS is generally in the trapping saturation regime for NIF relevant conditions but PIC simulations [6] show that, simultaneously, forward SRS is in the LDI regime. (Thus making the tortuous connection to the ionosphere experiments!) The ionosphere experiments can provide a paradigm of how successful modern nonlinear modeling can be for a well characterized electromagnetic pump wave and a smooth, well characterized, (ionospheric), plasma. How these lessons might be applied to the laser-plasma case will be briefly discussed. . Further details will be presented in a poster.

[1] H.C. Carlson, W.E. Gordon, and R.L. Showen, J. Geophys. Res. **97,** 6285 (1972)
A.Y. Wong,and R.J. Taylor, Phys. Rev. Lett. **27**, 644 (1971)
[2] M.P. Sulzer, Radio Sci. **21**, 1033 (1986)
[3] P.Y. Cheung, M.P. Sulzer, D.F. DuBois,and D.A. Russell, Phys.Plasmas **8**,802(2001)
D.F. DuBois, D.A. Russell, P.Y. Cheung, andM.P. Sulzer, Phys.Plasmas **8**,791(2001)
[4] D.F. DuBois,A.Hanssen, H.A.Rose, and D.Russell, J. Geophys. Res. **97**,15059(1992)
[5] K.Y.Sanbonmatsu,H.X.Vu, D.F. DuBois,andB.Bezzerides,Phys.Plasmas**7**,2824(2000)
[6]H.X.Vu,D.F.DuBois,andB.Bezzerides,Phys.Rev.Lett.**86**,4306(2001),PoP**9**,1745(2003)
[7] J.Kline et al to be published in Phys. Rev Lett. (2005)

For **oral presentation** at the 35th Anomalous Absorption Conference, June 27- July 1 (2005)

*Research Supported by USDOE under contract No.W-7495-Eng.36 and NSF Grant No.97-13563ATM

Evening Poster Session 2

8:30 - 11:00 PM

Reduction of Rayleigh-Taylor Instability Growth with Cocktail Irradiation

K. Otani, K. Shigemori, T. Sakaiya, S. Fujioka, A. Sunahara, M. Nakai, H. Shiraga, H. Azechi, and K. Mima

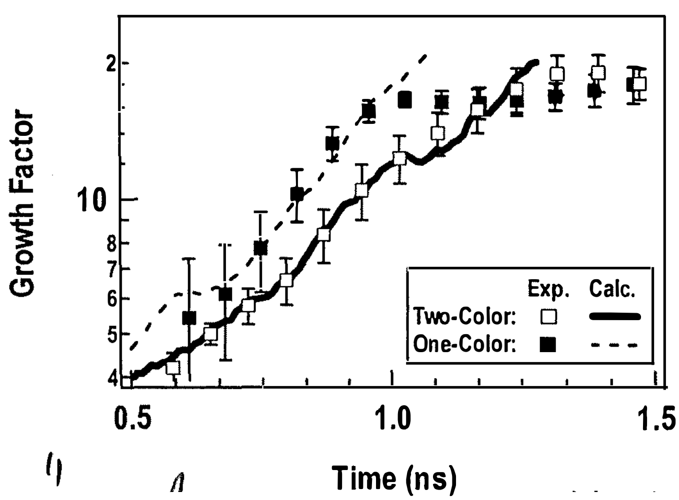
Institute of Laser Engineering, Osaka-university, Japan

In inertial confinement fusion with laser ablation, the Rayleigh-Taylor (RT) instability is a most critical problem at imploding fuel surface. The RT instability grows the slight perturbation on initial fuel target to be broken up and the fuel is not compressed enough. To design a high gain target needs to reduce the RT instability.

The RT instability grows exponentially in early phase, and its growth rate is described as the formula: $\gamma=\{kg/(1+kL)\}^{1/2}-\beta k v_a$, where g is the RT growth rate, k is the wave number of perturbation, L is the density scale length at ablation surface, b is a constant number (1.7 for polystyrene), and va is the ablation velocity ($v_a = dmdt/\rho_a$: dmdt is the mass ablation rate, ρ_a is ablation density), respectively.

Due to the pressure conversion efficiency, short wavelength laser is suitable for drive laser. However, longer wavelength laser is absorbed in hot corona plasma region and generates high-energetic electrons. The Maxwellian tails of hot electrons transport their energy further than the mean-free-path calculated by dispersion approximation (non-local electron heat transport). In cocktail laser irradiation scheme, two or more different wavelength laser irradiate to the target, short wavelength laser gives high pressure, and long wavelength laser generates high-energetic electrons and heat the ablation surface.

We have done the experiments on GEKKO-XII Nd-glass laser system to measure the parameters concerned of the RT growth by cocktail laser irradiation. Below figure shows the experimental result of the RT growth factor. It provided the reduction of the RT growth comparing to the case of only the short wavelength laser. And these results were well reproduced by ILESTA-1D radiation-hydrodynamic simulation code with Fokker-Planck treatment. We will show these experimental and calculation results on the presentation.



Planar Rayleigh-Taylor experiments on OMEGA.

A. Casner [#], J-P Jadaud, , S. Liberatore, D. Galmiche and M. Vandenboomgaerde.
CEA-DIF, BP 12, 91680 Bruyères-le-Châtel, France

Experimental results and simulations are presented concerning planar Rayleigh-Taylor instabilities made with CH(Br) on the OMEGA Laser Facility of the University of Rochester, Laboratory of Laser Energetics. We use a special hohlraum with an internal "Rugby" shape to improve absorption of 21° cone beams (in a 3 cones illumination configuration along P6/P7 axis). On each shot face-on and side-on radiography are performed on each shot in order to better constrain the FCI2 simulations. In view of some discrepancies between experimental results and simulations it seems difficult to infer the drive on the sample from the Dante measurements through the LEH. That is the reason why we plan for next campaign in July 2005 to perform also shock-break out measurements on Al steps. This, together with Dante measurements through the LEH and also with the CEA X-Ray spectrometer DMX, will give a more accurate characterization of the X-Ray drive incident on the sample. We also plan to perform Rayleigh-Taylor experiments with CH(Ge), one potential ablator for the LMJ. These experiments will be the first step toward a test-bed validation of CH(Ge) as an ablator on OMEGA and further on LiL.

alexis.casner@cea.fr

"Rayleigh-Taylor Instability in Decelerating Interface Experiments"

C.C. Kuranz, R.P. Drake, K.K. Killibrew, D.J. Kremer , D.R. Leibrandt, E.C. Harding,
University of Michigan
H.F. Robey, B.A. Remington, B. Blue, H.F. Hansen, M.J. Edwards, A.R. Miles,
Lawrence Livermore National Laboratory
J.P. Knauer, T. Boehly, *University of Rochester*
D. Arnett, *University of Arizona*

Our goal is to experimentally confirm or disprove the hypothesis that the Rayleigh-Taylor instability could be responsible for the observed transport of heavy elements form the core of SN1897A, a core-collapse supernova, into its outer layers. Observational astrophysicists have been unable to explain the x-ray or luminosity data from SN1987A. Strong hydrodynamic instabilities could be one explanation of the data. Computer simulations of SN1987A have not been able to reproduce the high velocity of heavy elements in the supernova, however, no simulations to date have taken into account three-dimensional effects. Our experiments bridge the gap between simulations and observations by using intense lasers to create an extremely large amount of energy in a small volume. Experiments performed at the Omega Laser facility use ~ 5kJ of laser energy to create a blast wave similar to those in supernovae. The blast wave crosses a perturbed interface with a density drop and produces Rayleigh-Taylor growth. By performing experiments with more complex initial conditions, we hope to observe the effect their complexity has on Rayleigh-Taylor instability.

Results from recent experiments will be presented. These experiments use a polyimide disk attached to a polyimide shock tube; within which is polyimide with brominated plastic tracer strip followed by a lower density C foam. The interface between the two materials has an initial 3D perturbation with a wavelength of 71 μm in two orthogonal directions and an amplitude of 2.5 μm. Some targets explore the effects of increasingly complex initial conditions on the Rayleigh-Taylor instability by adding an additional mode in one direction of the perturbation. The target is attached to a large gold shield to protect the film in our diagnostic from overexposure by light emitted from hot plasma. A new diagnostic technique using the direct exposure of x-rays onto film has greatly increased the resolution of these experiments. This work is supported by the U. S. Department of Energy under grants DE-FG03-99DP00284, DE-FG03-00SF22021.

Rayleigh-Taylor Instability in Spherically Stagnating Systems

H. Sakagami[1)], T. Okamoto[2)], M. Horikoshi[3)], and K. Nishihara[3)]
[1)]Theory and Computer Simulation Center, National Inst. for Fusion Science, 322-6 Oroshi-cho, Toki 509-5292, Japan
[2)]Personal Electronics Group, SANYO Electric Co. Ltd., 1-1 Daito, Sanyo-cho, Osaka 574-8534, Japan
[3)]Institute of Laser Engineering, Osaka University, 2-6 Yamada-oka, Suita, Osaka 565-0871, Japan

In inertial confinement fusion, the Rayleigh-Taylor instability is unavoidable during the implosion and can destroy spherical symmetry of a fusion target. It is, therefore, one of important research topics in this field to investigate this instability. The Rayleigh-Taylor instability in spherical geometry is quite different from that in planar geometry because acceleration and wavelength vary in space and time. Thus we have been investigating linear and nonlinear features of the fully three-dimensional Rayleigh-Taylor instability in spherically stagnating targets through numerical simulations.

As a Rayleigh-Taylor unstable interface is shrunk during the implosion and a radius of the interface is minimized at the maximum compression, we must set up the simulation system to capture the minimized interface with enough number of meshes. Recently advanced laser systems can be highly aligned and irradiate fusion targets more uniformly than ever, and the highly evolved fabrication technology can produce more precise spherical targets. So inspecting experimental results requires more precise simulations that calculate not only lower mode but also higher mode phenomena. Thus large-scale simulations are essential to analyze those experimental results with enough precision, and they will be accomplished only with parallel supercomputers. We have parallelized a three-dimensional fluid code, IMPACT-3D with High Performance Fortran on the Earth Simulator.

We have introduced a self-similar analysis to describe the stagnation dynamics, which includes the effects of spherical geometry, acceleration and wavelength varying in space and time. At the start of each simulation, a small perturbation was applied to the density profile of the self-similar solution at the contact surface. We have performed large-scale simulations with initial perturbations, which are given by a single spherical harmonics function of (6,3) or (12,6), and mode coupling with (6,3) and (12,6). Actually an initial perturbation mainly comes from the fact that fusion targets are irradiated with a finite number of laser beams. This laser irradiation system induces the perturbation with the shape of not the spherical harmonics function but a combination of icosahedron and dodecahedron related to the irradiation symmetry. We have also been investigating the Rayleigh-Taylor instability for initial perturbations with the combination of icosahedron and dodecahedron, including randomly arranged bubbles/spikes with 32 levels of initial amplitudes, randomly arranged only bubbles with 16 levels, randomly arranged only spikes with 16 levels, a specific bubble surrounded by bubbles or spikes with different levels, and a specific spike surrounded by bubbles or spikes with different levels. From all simulation results, we plotted growth rates of the Rayleigh-Taylor instability at the maximum compression as a function of initial perturbation amplitudes, and found that all data were fallen onto a universal curve. Namely, the growth rate seems to depend only on the initial perturbation amplitude regardless of many other conditions, and this characteristic is similar to that of the Richtmyer-Meshkov instability.

It is noted that the Earth Simulator Center claims more than 95% of vectorization ratio and more than 50% of parallelization efficiency to run the simulation code on the Earth Simulator, and we have cleared these severe criteria on using 1024x1024x1024 meshes and 128 nodes (1024 processors). Jobs can be easily submitted to the Earth Simulator through commonly used NQS-II system and typical runs can be done within 3 hours on 128 nodes of the Earth Simulator.

Collapsing Radiative Shock Experiments in Xenon on the Omega Laser

A.B. Reighard, R.P. Drake, K.K. Danneberg, D.J. Kremer, P. Susalla, M. Grosskopf, D. Leibrandt, T. Donajkowski (*U. MI*) C. Muscatello (*CWRU*); N. Meyer (*Carleton*); S.G. Glendinning, T.S. Perry, B.A. Remington, R.J. Wallace, D.D. Ryutov, J. Greenough (*LLNL*); J. Knauer (*LLE*); S. Bouquet, L. Boireau (*CEA Bruyeres*); M. Koenig, T. Vinci (*Ecole Polytechnique*)

A number of astrophysical systems involve radiative shocks that collapse spatially in response to energy lost through radiation, producing thin, dense shells with some structure. We report experiments intended to study such collapsing shocks. The Omega laser drives a thin slab of material at > 100 km/s through xenon gas at approximately 6 mg/cc. Simulations predict a collapsed layer in which the density will reach >20 times initial density, and in which thickness will near 100 μm as the distance traveled reaches ~2 mm. Both area and point-projection backlighting techniques have yielded images of a collapsed shock compressed to <1/25 its initial thickness (~45 μm), with average velocities >100 km/sec, decelerating in time.

Work at U. of M. supported by the U.S. DoE under grants DE-FG03-99DP00284, DE-FG03-00SF22021, and other grants and contracts.

35th[d] Annual Anomalous Absorption Conference
Fajardo, Puerto Rico
June 26 – July 1, 2005

TP6

High-Mach Number Relativistic Ion Acoustic Shocks

J. Fahlen, W.B. Mori
University of California, Los Angeles

Electrostatic ion acoustic shocks are found in many areas of plasma physics. They can be generated by lasers incident on thin-foils, by the ignitor laser in fast ignition, and by the transverse ponderomotive force in underdense laser-plasma experiments. In addition, they may also be important in astrophysics. Ion acoustic shocks can produce very energetic ions because the large electric potential jump across the shock front can trap and reflect ions. Existing theories for ion acoustic shocks assume that the electron temperature is non-relativistic. However, for the applications described above the electron temperature is typically in the relativistic regime. We calculate the speed of ion acoustic waves and we present a theory predicting the speed at which a shock with ion reflection can form in a plasma with relativistic electron temperatures. Corroborating particle in cell (PIC) simulations using the relativistic code OSIRIS are also presented.

Work supported by the DOE grant DE-FG02-03NA00065 and LLNL under W-07405-ENG48

When is 1/4 greater than 1/2?

Mordecai D. Rosen

Lawrence Livermore National Laboratory,

L-039, 7000 East Avenue, Livermore, CA 94551

Phone: (925) 422-5427; Fax: (925) 423-9208; E-mail: rosen2@llnl.gov

Abstract. We have been studying ways to optimize NIF hohlraums by using "cocktail" wall materials that can decrease the x-ray energy wall loss by about 18% (compared to conventional pure gold walls) due to their combined opacities. If oxygen contaminates the cocktail material and binds to it stoichiometrically, the increase in specific heat is enough to reduce the cocktail energy savings bonus by about 1/2, to only about 9%. One scheme to prevent this from happening is to coat the cocktail with a thin layer of pure gold which can keep out the oxygen. In the course of studying this scheme we have encountered the following, seemingly paradoxical, result: Typically the Marshak depth to which a NIF cocktail hohrlraum wall is heated is 8 microns. If we replace the first 1/4 of it by 2 microns of gold, we find that it too reduces the energy savings bonus of the cocktail by about 1/2, to only about 9% - thus this particular "cure" is not any better than the (oxygen) "disease" that it prevents. (Obviously, thinner coatings of gold will restore the energy savings bonus to closer to that of the pure cocktail). We look in detail at the Marshak wave energetics and explain why this "1/4" seemingly paradoxically affects 1/2 the energy savings. A combination of effects play a role- the kinetic energy is substantially localized to the first 1/4 of the Marshak depth, and the optical depth of that Au layer is less than the equivalent cocktail and thus lets through more flux. We quantitatively analytically show how all these effects conspire to "make 1/4 act like 1/2".

This work was carried out under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.

Topic: Radiation Hydrodynamics

Preference: Poster Presentation

Gas-filled Hohlraum Drive with a Composite Laser Pulse Shape for Be Microstructure Experiments*

J. A. Cobble, B. G. Devolder, N. M. Hoffman, D. C. Swift, T. E. Tierney, D. L. Paisley
Los Alamos National Laboratory

Laser-plasma experiments on the National Ignition Facility (NIF) will be driven for as long as 20 ns for a variety of campaigns from radiation hydrodynamics and material studies to attempts at thermonuclear ignition. To prepare for those experiments, the Omega laser at the University of Rochester is being pressed to and beyond its original design capability. For example, most present Omega experiments are 1 – 3 ns in duration. However to evaluate instability growth rates in Be, a candidate for NIF ignition-capsule design, it is advantageous to drive the Be samples for longer periods of time so that more instability growth results in a more easily diagnosed material response. To that end, we have designed, deployed, and characterized a 6-ns radiation drive for an Omega hohlraum, which is suitable for such studies. Multiple Omega laser beams have been used to heat a Au hohlraum to create a tailored 6-ns radiation pulse.

The cylindrical hohlraum, like future NIF targets, is gas filled, in this case with methane. It has a single 1.2-mm laser entrance hole. Its diameter and length are 1.6 and 1.2 mm respectively. The laser drive is a composite of two distinct pulse shapes: a 3.8-ns foot pulse carried by three beams and a 2.5-ns triangular pulse carried by ten beams and delayed to near the end of the foot. Total input energy exceeds 4.25 kJ. The radiation pulse, characterized by soft x-ray spectroscopy (Dante) and velocity interferometry, increases to 60 eV in 0.5 ns, gently increases until 2.5 ns, then ramps up less gradually to a peak value approaching 150 eV at 5.8 ns. We have assessed backscatter losses from laser-plasma instabilities (<10% into the lens) and find that methane is suitable for useful experiments. Growth factors of ~20 are predicted for this hohlraum drive.

Active and passive shock-break-out diagnostics show that 40-μm thick Be-Cu (0.9% Cu by atom) samples are preheated even with this soft drive. Be samples at the rear of the hohlraum have taken the form of planar disks, sinusoids with 100-μm period and 2.5-μm amplitude, and steps (30 and 60 μm thick). Results will be shown from face-on x-ray radiography, side-lighting, and hohlraum characterization.

This longer-than-average Omega radiation drive approximates conditions needed for the ignition program and is useful for a variety of laser-plasma experiments including validation of Be as a NIF ablator material.

* This work performed under the auspices of the United States Department of Energy, contract no. W-7405-ENG-36.

Towards the optimal double-shell ignition target via careful design and experiments*

Jose L. Milovich, Peter A. Amendt, Michael M. Marinak and Harry F. Robey
Lawrence Livermore National Laboratory,
University of California, Livermore, CA USA 94550

Abstract

Over the last few years double-shell (DS) targets have been actively pursued as a complementary approach to the cryogenic baseline design in order to maximize the prospects for ignition on the National Ignition Facility (NIF). This renewed interest comes from the fact that DS targets have the benefit of preparation and fielding at room temperature, the potential for lower laser backscatter, and the reduced need for careful shock timing. Additionally, recent experiments[1] at the Omega laser facility have demonstrated unprecedented performance - in line with the best performing single shell targets of comparable convergence. This encouraging result has motivated an increased design effort aimed at determining the major mechanisms that affect the performance of DS targets. The initial NIF DS design[2] was based on the optimization of yield by a reduction of the deleterious mixing occurring at the fuel/pusher interface after deceleration onset. A subsequent analysis[3], however, has revealed that this original design was quite susceptible to Rayleigh-Taylor instabilities occurring at the outer surface of the inner shell prior to deceleration onset. This instability was strong enough to cause shell disruption and an accompanying reduction in thermonuclear yield. The goal of subsequent work[4] was to identify and propose alternative NIF DS designs to control this instability. In the present study, we identify and quantify the effect of several additional sources of neutron yield degradation by performing highly-resolved two-dimensional computer simulations of DS targets with a variety of defects. To demonstrate our ability to model the current DS database, we have initiated a systematic study of both past and current Omega DS experimental campaigns. Specifically, the all-glass inner-shell design[5], which gave consistently poor performance, and the all-plastic DS[1] with its still unexplained 65% yield degradation, are the focus of this simulation effort. Our simulations suggest that a dominant source of yield degradation is imprinting of the outer-shell hemispherical joint onto the inner shell via the transmitted shock. The challenging manufacturing and fabrication of DS targets can easily lead to joint defects from misaligned or incompletely bonded hemispherical outer shells. These unintended defects can severely degrade neutron production. Finally, we incorporate our current understanding of DS degradation mechanisms to put forth an improved glass inner-shell design for an upcoming Omega experimental campaign.

1. P. Amendt *et al.*, Phys. Rev. Lett. **94**, 065004 (2005).
2. P. Amendt *et al.*, Phys. Plasmas **9**, 2221 (2002).
3. J. L. Milovich *et al.*, Phys. Plasmas **11**, 1552 (2004)
4. J. L. Milovich *et al.*, *IFSA Proceedings 2003*, p. 174, Monterey, USA.
5. W.S. Varnum *et al.*, Phys. Rev. Lett. **84**, 5153 (2000).

* This work was performed under the auspices of U.S. DOE by the LLNL under Contract No. W-7405-Eng-48.

Beam Conditioning Mitigation of Laser Plasma Instabilities at the National Ignition Facility

A. B. Langdon, E. Williams, D. Hinkel, S. Dixit, R. Kirkwood,and D. Munro
Lawrence Livermore National Laboratory
Livermore, CA

Several beam conditioning measures are planned for the National Ignition Facility. These include phase plates, smoothing by spectral dispersion (SSD), polarization smoothing (PS), and a color shift between inner and outer beam cones ("two color"). The latter reduces inter-cone power transfer in the plasma flowing out of the entrance hole in indirection drive ignition targets by introducing a frequency mismatch between the beam cones. We present simulation studies and analysis of the interaction of SSD and power transfer for beams smoothed by phase plates. In part, SSD effectively broadens the sonic resonances, eroding the mismatch, and we predict also that SSD also can introduce an oscillation in the power transfer at the modulator frequency of 17 GHz. However, a flexible span of "two color" wavelength shift minimizes power transfer. We also present analysis of effects of SSD on beam spray due to forward Brillouin scatter near the threshold for filamentation.

Principal Author: A. B. Langdon, L-038,
Lawrence Livermore National Laboratory
P.O. Box 808
Livermore, CA 94550
(925) 422-5444
ablangdon@llnl.gov

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

UCRL-ABS-211221

***Title:** Simulations of radiographic detection of NIF ignition capsule defects

Authors: Brian Spears, ...

Abstract:
Defects in beryllium ablator NIF ignition targets, such as voids or surface roughness, serve as seeds for Rayleigh-Taylor instability. Multiple radiographic techniques are being considered to test for the presence of such defects. The first technique, called precise radiography, illuminates a rotating shell for many revolutions while binning data by angle. This technique leads to very high sensitivity and can therefore detect small variations in signal intensity introduced by defects. An alternative method, phase contrast imaging, takes advantage of phase changes in waves traversing the capsule to increase the contrast of the edges of features. This method is sensitive to the spatial frequency of features and can be tuned to enhance features of a particular spatial wavelength. Tight specifications on NIF ignition capsules require the ability to detect small defects (e.g, voids of 5 micron diameter). This in turn requires large signal-to-noise ratio and fine resolution from both techniques. Numerical simulations of ignition capsules viewed through both diagnostics have been employed to determine minimum detectable defect sizes and required x-ray source coherence and intensity. Simulation results will be presented and the overall effectiveness of both techniques at detecting defects within NIF specifications will be discussed.

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

35th Anomalous Absorption Conference 2005

Simulation of Laser-Generated High Energy Density Halfraum Environments

M. J. Schmitt, E. S. Dodd, G. R. Magelssen, I. L. Tregillis,
S. R. Goldman and B. G. DeVolder

Los Alamos National Laboratory, MS B259, Los Alamos, NM 87544

Email mjs@lanl.gov, Phone: (505)665-7522, Fax: (505)665-7725

Topic: Parametric Instabilities | Poster preferred

Generating high radiation temperature environments using high intensity ($\geq 10^{15}$W/cm^2) is important for the study of material properties and dynamics under extreme conditions. We have used the radiation-hydrodynamics code, Lasnex, to predict the conditions that can potentially be achieved in single-ended halfraums using laser energies in the range of 10 to 100 kJ at a wavelength of 0.35 μm. Integral to this study is the estimate of energy loss from laser plasma instabilities. We have used the code LIP to estimate the level of backscatter from stimulated Brillouin and stimulated Raman scattering. We show that peak radiation temperatures are achieved using short, ~1 ns pulses. We will discuss the effects of low density fill materials on the conditions in the halfraum. Materials including gases (with windows) and low density foams will be addressed.

35th Annual Anomalous Absorption Conference
El Conquistador Resort, Puerto Rico
June 27-July 1, 2005

A modified hydrodynamics model for handling plasma self-collision in numerical simulations of ICF hohlraums

O. Larroche
CEA/DIF, BP 12, 91680 Bruyères le Châtel, France

Plasma collisions occurring inside ICF hohlraums lead to uncertainties in the interpretation of experimental data, due to the inaccurate rendering of this phenomenon in standard hydrodynamics codes. Specifically, the local density and radiation increases observed in plasma collision regions are believed to be over-estimated in numerical simulations. This can be traced back to the fact that plasma collisions and/or interpenetration at high velocities intrinsically deviate from local thermodynamical equilibrium, near which the Navier-Stokes equations are valid, due to the large collision times prevailing in those situations.

In the past some plasma collision situations have been satisfactorily simulated[1,2] by multifluid codes where each colliding plasma component is described through its own set of hydrodynamical quantities (namely, ion density and temperature) and allowed to move with respect to other components at arbitrary velocity. However, turning large hydrodynamics codes used for the routine interpretation of experiments into multifluid codes is not considered a realistic option. In this work, an alternative option is presented, whereby a modification of the standard hydrodynamics equations might yield a less general, but still satisfactory treatment of plasma collision situations. In addition, this treatment would naturally apply to plasma self-collision in convergent geometry (e.g., on-axis collisions in cylindrical ICF hohlraums), which is not amenable to the frame of a multifluid formalism.

The principle of this proposal is to treat the full ion pressure tensor (and, possibly, ion heat flux tensor as well) as a dynamical variable, instead of just its isotropic part as is usually done, with pressure anisotropy rigidly bound to the velocity gradient through the viscosity coefficient. This is consistent with the large collisional relaxation times involved in the thermalization of colliding/interpenetrating plasmas. Such a formalism has been proposed in the past for modeling the mildly collisional plasmas of stellar winds[3].

In the present work, first investigations of the validity of this principle will be given through the calculation of 1-D plasma collisions with our multifluid code MULTIF, using both single- and multifluid descriptions of the same systems. We will demonstrate that a properly defined collision time can bring the single-fluid calculation in good agreement with the reference multifluid one, even when the plasma state is actually that of an interpenetration at very high relative velocity. The modified hydrodynamical equations to be solved in a cylindrical 2-D version of this model will then be presented.

---

[1] C. Chenais-Popovics et al, Phys. Plasmas **4**, 190 (1997).
[2] P. W. Rambo, J. Denavit, Phys. Plasmas **1**, 4050 (1994).
[3] S. Cuperman, I. Weiss, M. Dryer, Astrophys. J. **239**, 345 (1980).

A comparison of laser backscattering measurements in quasi-homogeneous plasmas with calculated linear gains for stimulated backscattering and self focusing instabilities*

J. C. Fernández, D. S. Montgomery
Los Alamos National Laboratory, Los Alamos, NM 87544, USA
B. B. Afeyan
Polymath Research Inc., Pleasanton, CA 94566, USA
A. J. Schmitt
Naval Research Laboratory, Washington DC 20375-5346, USA

We have a significant database of experimental results on laser backscattering from quasi-homogeneous plasmas. These experiments were fielded at the Nova laser facility, located at the Lawrence Livermore National Laboratory. Specifically, these experiments used gas-filled hohlraums designed to provide long-scale, nearly homogeneous plasmas approaching the conditions expected within ignition hohlraums to be fielded at the National Ignition Facility. While it was impossible to reproduce simultaneously every relevant laser-plasma instability (LPI) figure of merit (FOM) from a NIF ignition design in the much smaller Nova facility, these experiments allowed us to vary some of these FOMs over a NIF-relevant range, specifically the linear gains for self focusing (over the length of a typical speckle) and for stimulated backscattering instabilities (over the whole target). In this paper, we concentrate on the results on laser backscattering due to stimulated Raman backscattering (SRS) and stimulated Brillouin backscattering (SBS). Along with other more recent experiments on NIF, this informative multi-year Nova campaign indicated that SRS and SBS saturation levels are the result of highly non-linear processes. In particular, calculated instability gains from linear convective theory are not good quantitative predictors of the observed laser-reflectivity levels. This is not surprising given the large calculated linear gains typical of these plasmas. However, the question of whether calculated linear gains are a good *qualitative* predictor of the measured reflectivities seems to persist. We find that in these plasmas, the answer is no. For example, we observe large SRS reflectivities in cases when the calculated linear gain exponent is as low as 9, which should result in small reflectivity. On the other hand, we observe negligible SBS reflectivities in cases when the calculated linear gain exponent is an order of magnitude higher (> 100).

Another interesting question is whether laser self focusing leads to increased reflectivity, due to an increase in the linear gain rate with an effectively higher intensity, filamented laser beam. We find that the laser reflectivity does not correlate with the value of the filamentation FOM, as it is varied from very low to very high values. Simulations of the filamentation process explain why this observation is not surprising. As a laser beam filaments, increased laser-speckle intensity and angular spraying of the light is inevitably accompanied by a typical axial intensity profile which is made up of alternatively high and low intensity regions. The correlation lengths of the high intensity regions will be far shorter than the original speckle length. Therefore, even in a linear-theory sense, where convective gain is calculated as an axial sum or integral, filamentation does not imply higher backscattering levels. In this paper, we present the experimental observations and simulation support that justifies our conclusions.

* This work supported by the NNSA of the US DOE.
Corresponding author: Juan C. Fernández, Los Alamos National Laboratory, MS E526, Los Alamos, NM 87544, USA; juanc@lanl.gov; FAX: 1 505 665 4409

Abstract for Poster Presentation:

35th Annual Anomalous Absorption Conference

June 26 - July 1, 2005, Fajardo, Puerto Rico

Vlasov, fluid, and particle models of low-temperature, collisionless, relativistic laser-plasma interactions

B. A. Shadwick[1,2], G. M. Tarkenton[2], C. B. Schroeder[1], E. Michel[3], and E. Esarey[1,3]

[1] *LOASIS Program, Lawrence Berkeley National Laboratory, Berkeley, CA 94720*

[2] *Institute for Advanced Physics, Suite 199, 10875 US Hwy 285, Conifer, Colorado 80433*

[3] *Department of Physics, University of Nevada, Reno, NV 89557*

We present a warm fluid model, derived using a closure based on a small momentum spread assumption, that can be applied to short-pulse lasers propagating in underdense plasmas [1]. The fluid model predicts that the plasma response is largely insensitive to the details of the phase-space distribution. In addition, there is little plasma heating in response to a short-pulse laser. We present a new formulation for the Vlasov-Maxwell equations - a moving phase-space grid - where the bulk motion in momentum space is removed by an exact transformation [2]. Numerical methods based on this formulation are orders of magnitude less computationally demanding than those that solve the Vlasov equation on a fixed phase-space grid. Using this method we have solved the Vlasov-Maxwell equations for various initial distributions and confirmed the predictions of the fluid model that the bulk fields are insensitive to the details of the distribution. In the quasistatic case, we show excellent agreement between the solution of the warm-fluid equations and those of the Vlasov equation. The warm-fluid model is compared to the particle-in-cell model and it is found that the latter model, at typical numerical resolution, predicts a momentum spread in the laser that is unphysically large.

[1] B. A. Shadwick *et al.*, Phys. Rev. Lett. **93** 175002 (2004).

[2] B. A. Shadwick *et al.*, Phys. Plasmas **12**, 056710 (2005).

This work was supported by the Office of Science, High Energy Physics, U.S. Department of Energy under Contract No. DE-AC03-76SF0098.

TP16

A Simple Model for Microchannel Plate Output

E. C. Harding[1], R. P. Drake[1], J. L. Weaver[2]

[1]University of Michigan, Ann Arbor, MI
[2]Naval Research Laboratory, Washington, DC

Microchannel plates (MCPs) are an essential component in an imaging diagnostic known as an x-ray framing camera, which is currently in use by NIF, Omega, Nike, and Z to image radiation imploded targets. An MCP is used to convert incident x-ray photons into electrons with typical gains of 10^2 to 10^4. A variety of parameters, such as photocathode material type (Au, Ni ,CsI), photocathode coating depth, and MCP bias angle, effect the gain and gain variations in the MCP electron output. This poster presents initial results of a simple 3D MCP model along with an experimental comparison. Several ideas for increasing MCP gain and reducing gain variations are presented.

Work supported by the Naval Research Laboratory, DoE, and Livermore National Laboratory

Wednesday, June 29th, 2005

9:00 - 11:00 AM	**Oral Session: LPI/Parametric Instabilities** **Session Chair: W. Seka**
10:40 - 11:00 AM	**Coffee Break**
11:20 - 12:40 PM	**Oral Session: Ionospheric Modification** **Session Chair: D. S. Montgomery**
7:30 - 10:00 PM	**Conference Banquet** **Beyond the Beautiful Beaches: The Urgency and Challenges of Establishing a Tsunami Warning System in the Caribbean** **C. G. von Hillebrandt**

Oral Session 5

Laser Plasma Interactions/ Parametric Instabilities

Session Chair: W. Seka

9:00 - 11:00 AM

Nonlinear Evolution of Stimulated Raman Scattering driven by a RPP Laser Beam in a 2D Inhomogeneous Plasma

Th. Fouquet[1,2], S. Hüller[1], and D. Pesme[1]

[1] Centre de Physique Théorique, Ecole Polytechnique
91128 Palaiseau Cedex, France

[2] CEA-DIF, BP 12, 91680 Bruyères-le-Châtel, France

We studied the nonlinear evolution of Stimulated Raman Scattering in the case of a 2D inhomogeneous under-quarter critical plasma irradiated by a Gaussian or a RPP laser beam.

We designed a new numerical code, based on the generalization to multidimensional space of equations described in Ref. 1. Namely, the incident and backscattered waves are described within the paraxial approximation. The longitudinal waves are described within a fluid-like description, in the framework of the Zakharov equations in which the collisional and Landau dampings are included.

In order to be able to describe waves propagating outward without artificial reflection, we use a combination of artificial dampings and of vanishing coupling constants for the boundary conditions. In the case of a linear density profile, special attention had to be given to the spatial smoothness of these artificial parameters conditions in order to avoid transforming spatial amplification into unphysical absolute instability.

We will present first results corresponding to monospeckle and RPP irradiation.

[1] H. A. Rose, D. F. DuBois, and B. Bezzerides, Phys. Rev. Lett. **58**, 2547 (1987).

Two-dimensional Simulations of Stimulated Brillouin Scattering

J-C. Adam [1], F. Detering [1], A. Héron [1], S. Hüller [1],
P-E. Masson-Laborde [1, 2], D. Pesme [1], C. Riconda [3]

[1] *Centre de Physique Théorique, Ecole Polytechnique 91128 Palaiseau Cedex, France*

[2] *CEA-DIF, BP 12, 91680 Bruyères-le-Châtel, France*

[3] *CELIA, UMR CNRS-Université Bordeaux 1-CEA, 33405 Talence,France*

We studied the nonlinear evolution of Stimulated Brillouin Scattering in the case of a 2D plasma irradiated by a Gaussian laser beam[1]. In order to assess the role of electron kinetic effects in SBS saturation, we compared the results corresponding to a full PIC code (kinetic PIC electrons and ions) with those obtained from a hybrid code similar to BZOHAR[2] (kinetic PIC ions and Boltzmann fluid electrons). We also compared the results of these full PIC/hybrid codes with those obtained from a mode coupling code in which the fundamental component of the SBS generated IAW together with its harmonics and sub-harmonics are retained, and in which the kinetic effects are modelled by a nonlinear frequency shift.

[1] B. I. Cohen, L. Divol, A. B. Langdon, and E.A. Williams, private communication.

[2] B. I. Cohen, B. F. Lasinski, A. B. Langdon, and E.A. Williams, Phys. Plasmas **4**, 956 (1997).

35th Annual Anomalous Absorption Conference
Fajardo Puerto Rico.
June 27th – July 1st 2005

Demonstration of Polarization Dependent Backscatter in Multi-Beam Laser Plasma Interaction

R, K. Kirkwood, C. Niemann, A. B. Langdon, E. A. Williams, B. I. Cohen,
L. Divol, S. H. Glenzer, L. J. Suter. O. L. Landen
Lawrence Livermore National Laboratory

Recent experiments on the interaction of multiple laser beams in large scale plasmas have studied the effect of the relative orientation of the electric field vectors in the two beams on the stimulated scattering they produce. Gas filled 'gas bag' targets are pre-heated with up to 40 beams of the Omega laser to produce a hot plasma with a uniform plateau of ~6% critical density where two high intensity beams interact. Earlier Thomson scattering measurements of the location of the Langmuir waves produced by the SRBS showed the waves are large in the region between the target center and the incident edge of the plateau region during the first 0.5 ns of the interaction beam pulse. We point a pump beam and a near counter-propagating probe beam, each with 500J in a 1ns pulse (at 351 nm wavelength), to cross at at 25° angle, 100 microns away from target center, and toward the incident pump beam, and use phase plates to produce ~200 micron diameter spots on both beams. First we compared the SRBS in three cases , pump beam only, pump and probe beam with the polarizations aligned, and pump and probe beam with the polarizations perpendicular. We find that the early time scattering drops by ~ 0.65x in the presence of the polarization aligned probe, which is significantly lower than in either the single beam case or the case with the perpendicularly polarized probe. This difference in the early time scattering is also larger that the shot to shot reproducibility. A second experiment was then performed at ~7% critical density and with 11Å of SSD smoothing, which compared the probe aligned and probe perpendicular cases, and showed an even larger reduction of the late time ($t > 0.5$ ns) scattering in the aligned case. These observations suggest that the pondermotive force produced by the product of the fields of the two beams can effectively de-tune the SRBS interaction and that the relative polarization of multiple intersecting beams is important in determining the power scattered by the plasma.

[1] S. Depierreux, et al. in preparation

This Work was performed under the auspices of the U.S. Dept. of Energy by University of California Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48.

(Prefer Oral Session)

Schroeder

WO4

Abstract for Oral Presentation:

35th Annual Anomalous Absorption Conference

June 26 - July 1, 2005, Fajardo, Puerto Rico

Warm Wavebreaking of Nonlinear Laser-Driven Plasma Waves

C. B. Schroeder, E. Esarey†, and B. A. Shadwick

LOASIS Program, Lawrence Berkeley National Laboratory, Berkeley, CA 94720

We present a calculation of the maximum amplitude of a nonlinear electron plasma wave, valid for nonrelativistic plasma temperatures and arbitrary wave phase velocities, that can be applied to plasma waves driven by short-pulse laser-plasma interactions. This is in contrast to previous calculations of the wavebreaking limit, which are not valid in the regime of present laser-plasma interaction experiments. Nonlinear electron plasma waves with relativistic phase velocities driven by intense short-pulse laser-plasma interactions have been produced in the laboratory and used for charged particle acceleration. Short-pulse (sub-ps) intense laser-plasma interactions access a physical regime where the plasma electrons experience relativistic motion while the plasma temperature (electron momentum spread) remains small. The nonequilibrium plasma is typically created by the laser through photoionization and the laser-plasma interaction occurs on a time-scale short compared to the ion motion and the collision frequency. We analyze the nonlinear electron plasma waves excited by intense short-pulse lasers propagating in underdense plasmas using a warm, relativistic fluid model of a nonequilibrium, collisionless plasma. Properties of the nonlinear plasma wave, such as the plasma temperature evolution and nonlinear wavelength, are examined. The maximum amplitude of the plasma wave is shown to increase in the presence of a laser field. The relation between the wavebreaking limit and particle trapping is discussed. These results set a limit to the achievable field gradient in laser-plasma-based accelerators.

† Also at Department of Physics, University of Nevada at Reno, Reno, NV 89557

This work was supported by the Office of Science, High Energy Physics, U.S. Department of Energy under Contract No. DE-AC03-76SF0098.

WO5

Systematic Study of Laser-Plasma Instability Predictive Capability through Linear Gain Post-Processing of Radiation Hydrodynamics Simulations

N. B. Meezan, R. L. Berger, L. Divol, D. E. Hinkel,
O. S. Jones, E. A. Williams, S. Glenzer, and L. J. Suter
Lawrence Livermore National Laboratory, Livermore, CA USA 94550

Laser fusion targets must control laser-plasma instabilities (LPI) such as stimulated scatter or filamentation in order to perform as designed. The radiation-hydrodynamics codes used by designers to model these targets do not incorporate physical LPI models. The codes that do simulate detailed LPI physics, such as particle-in-cell (PIC) codes and paraxial wave/hydro codes (e.g., pF3d) are too computationally expensive to use as everyday design tools. Post-processed linear gain calculations provide an inexpensive, semi-empirical tool to qualitatively describe the LPI behavior of a target. One can attempt to evaluate a given target's risk for stimulated Raman (SRS) or Brillouin (SBS) backscatter by calculating the spatially-integrated linear gain coefficient along a laser beam path. Similarly, the filamentation figure of merit (FFOM), an expression of the ponderomotive filamentation gain-per-speckle-length, is used to evaluate laser propagation. Designers can combine detailed radiation-hydrodynamics simulations with these linear gain analyses to attempt to "design around" LPI in fusion targets.

This work aims to systematically explore the usefulness of linear gain post-processing as a predictor of LPI in fusion targets. We present an analysis of a broad range of experiments, including "historic" high and low backscatter targets from Nova; 2ω gas targets on the OMEGA and HELEN laser facilities; and recent experiments on NIF Early Light. We also attempt to include the effects of SSD and polarization smoothing. Finally, we apply the technique to recent NIF ignition hohlraum designs.

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

Prefer oral

PARTICLE-IN-CELL SIMULATIONS OF THE $2\omega_p$ INSTABILITY

F. S. Tsung, W. B. Mori --- UCLA*, B. B. Afeyan --- Polymath Research Inc.**

In the past few years we have used our particle-in-cell code OSIRIS to study the $2\omega_p$ instability in a single hot spot. Recently, with the advances in computing as well as a renewed interest in this instability in many ICF scenarios, we have extended our simulation study to look at this instability in many new scenarios. In the past year, we have performed new simulations, trying to verify the theoretical model proposed by Afeyan and Williams in 1997 ("A variational approach to parametric instabilities in inhomogeneous plasmas III: Two-plasmon decay", B. B. Afeyan and E. A. Williams, *Phys. Plasmas*, **4**, p. 3827 (1997)). In the nonlinear stage of the instability, the plasma density flattens due to the interaction of plasmons. While these activities are highly localized to the resonant layer of the $2\omega_p$ instability (usually a few microns in length) this plateau can enhance the linear growth if the density of the said plateau is close to the resonance. This is a possible mechanism for the recurrence of the $2\omega_p$ instability after the initial saturation. In the past year, we have isolated this effect by studying the linear stages of the $2\omega_p$ instability in a parabolic density profile. Our simulations have shown good agreement between simulations and the theory presented by Afeyan et al. Additionally, we have also begun to look at the effect of oblique laser incidence and we will compare these results with linear theory.

* Work supported by DOE and NSF.
** Work supported by NRL.

Oral Session 6

Ionospheric Modification

Session Chair: D. S. Montgomery

11:20 - 12:40 PM

WO7

The High frequency Active Auroral Research Program (HAARP) Facility

Robert A Jacobsen, Michael McCarrick (BAE Systems - ATI)
Ed Kennedy (NRL), Paul Kossey (AFRL)

The complete 3.5 MW (radiated power), 2.8 to 10 MHz, 12x15 element HAARP array, being constructed in Gakona, Alaska, will become fully operational in 15 to 18 months. This talk will review the evolution of this important research tool from the 3x6 element engineering development array, in which the transmitters and antenna electronics were developed; operations with the 6x8 element array which lead to optimization of the control system, to provide a functional physicist/machine interface, and preview the completed array. The predicted performance of the completed array, based on modeling and the operation of the 6x8 array, will be presented and the design of key array components reviewed.

Artificial Optical Emissions Produced at the HAARP Facility

T. Pedersen, E. Gerken, M. Kosch, F. Djuth, E. Mishin, D. Sentman

Since the first optical observations were made at the HAARP facility in 1999, optical phenomena at a number of wavelengths have been generated and observed over a wide range of transmitter frequencies, power levels, beam orientations, and ionospheric conditions, and have led to significant improvements in our understanding of the mechanisms operating in the plasma. The most pronounced feature of artificial optical emissions at HAARP is the large enhancement occurring in a spatially limited spot centered on the magnetic field direction. Early measurements of this effect demonstrated the presence of significant suprathermal 557.7 nm green line emissions at high frequency / high effective radiated power (ERP), detectable 630.0 nm red line emissions at 10% power, small-scale structure within the emission region, an unexplained delay in the green line rise time, and continuation of emissions up to 0.5 MHz beyond the peak critical frequency. Recent experiments carried out the past two winters have greatly increased the range of observed optical phenomena to include energetic green and near-infrared (777.4 nm) emissions at extremely low power near the 2nd harmonic of the electron cyclotron frequency, and bright artificial speckles created in a natural pulsating aurora as a result of short-period heating in the auroral E layer. Recent gyroharmonic experiments and improved optical sensors have shown significant structure including ring-like features near the beam edges and drifting small-scale irregularities near the beam center, especially near the ionospheric critical frequency, and have also produced indications of multiple excitation mechanisms operating over certain altitude/frequency regimes. These experiments have also shown the onset delay to result from spatial reconfiguration within the beam during the first minute of heating, and have allowed optical emissions to be detected over the full range of HAARP beam orientations to make quantitative measurements of the efficiency enhancement in the magnetic zenith.

Combined Radar and Radio Observations of Ionospheric Modification Experiments at HAARP

Brenton Watkins, Shin-ichiro Oyama, William Bristow, John Hughes,
Geophysical Institute, University of Alaska,
Fairbanks, AK 99775

Craig Heinselman, SRI International,
Menlo Park, CA 94025

Paul A. Bernhardt, Plasma Physics Division
Craig Selcher, Information Technology Division
Naval Research Laboratory, Washington, DC 20375

In February 2005, the High-Frequency Active Auroral Research Program (HAARP) facility was used to provide multi-sensor diagnostics of the high-power radio wave interactions in the ionosphere over central Alaska. The objective of the measurements was to compare ground diagnostics of nonlinear wave interactions produced as electromagnetic waves with effective radiated powers of 100 MW. Three simultaneous radio/radar instruments were used for the observations. These were (1) the UHF frequency Advanced Modular Incoherent Scatter Radar (AMISR) at HAARP, (2) the Stimulated Ionospheric Electromagnetic Radio Receiver Array (SIERRA) spectrum monitoring network between the Gulf of Alaska and Fairbanks, and (3) the HF Super Dual Auroral Radar Network (SuperDARN) radar at Kodiak, Alaska. By scheduling these simultaneous radio/radar measurements with HAARP Operations a broad view of photon (Electromagnetic Wave), plasmon (Plasma Waves), phonon (Ion Sound Wave), and density irregularity interactions was measured. These measurements have provided validations of theories on high power wave interactions in the ionosphere. New discoveries during this campaign include (1) duty cycle dependence of Doppler spread of SuperDARN radar backscatter, spatial dependence of relative down-shifted and up-shifted stimulated electromagnetic emission (SEE) intensities from the SIERRA array, and the first enhanced ion and plasma lines obtained using HAARP.

In Situ Diagnostics of HF Driven Non-Linear Plasma Interactions and Turbulence in the Ionosphere

Carl L. Siefring, Paul Rodriguez, and Paul Bernhardt
Naval Research Laboratory, Washington, DC 20375

Lynette Gelinas, and Michael Kelley
Cornell University, Ithaca, NY

Ionospheric heating experiments examine non-linear interactions between high-power HF radio waves and the Earth's ionospheric plasma. In the ionospheric case, the relatively large scale-sizes of the heated volume (tens of kilometers), the heating electromagnetic pump wave (tens of meters), the driven electrostatic waves (tens of meters down to centimeters) and plasma density structures (tens of meters down to centimeters) makes it is possible to diagnose some of the microphysical details of the interaction. There are a few examples where sounding rockets have been used as a diagnostic. The first in situ measurements were made in the Tromso heater beam in 1980. There have also been a few attempts at using satellites for the same purpose.

In 1992, a NASA Sounding rocket campaign was run in Puerto Rico and utilized the Arecibo Heater for a number of experiments. Two of the rockets flown into the heater carried electric field, plasma density, and HF radio wave instrumentation. These were the Naval Research Laboratory Ionospheric Focused Heating (IFH) experiment and the Cornell Soliton Experiment. Another instrumented rocket, the Langmuir Turbulence (LaTur) experiment was launched into the Arecibo Heater in a 1998 NASA campaign. Unfortunately the Soliton rocket veered to the west of the heater beam and heater partially malfunctioned during the LaTur experiment. All three experiments showed that the heater causes development large-scale field aligned irregularities after. However, the detection non-linear and turbulent effects were limited in Soliton and LaTur cases.

We will primarily discuss the IFH experiments where clear correlations between HF pump waves, induced HF plasma waves, induce density structures and induced low-frequency waves can be seen. The IFH experiment used a chemical release to deplete the ionospheric electron density. The chemical was released just as the payload reached the HF reflection altitude, the main interaction region. The payload, thus, flew through two interaction regions, once partially in the undisturbed ionosphere and once as it exited the chemical release and the electron density was returning to ambient. We will show correlations of the spectra at HF (Electromagnetic + Langmuir waves) and of the spectra of low-frequency by-products. These spectra indicated that a non-linear wave matching conditions must be met. We will also show the correlation of small-scale electron density structures with bursts in wave activity. We believe that the IFH experiment indicates non-linear interactions and turbulence at both the critical reflection altitude $f_{pump}=f_{plasma}$ and at the quarter critical frequency $f_{pump}=f_{plasma}/4$. The LaTur rocket showed direct coupling to Z-mode and interesting interactions above the critical ($f_{pump}=f_{plasma}$) altitude whenever f_{plasma} was equal to a harmonic of the local electron cyclotron frequency.

Satellite payloads can also be used to diagnose HF interactions. A satellite does not fly through the interaction region very often. However, facilities that can be steered and have frequency agility, such as HAARP, increase the likelihood dramatically. We are planning future experiments using the Canadian ePOP/ Cassiope satellite, which is well instrumented for detecting HF interactions. The plan is to coordinate passes over the HAARP facility and measure the HF, low frequency electric fields, low-energy particles and the background ionosphere.

Conference Banquet
7:30 - 10:00 PM

Banquet Presentation

Beyond the Beautiful Beaches: The Urgency and Challenges of Establishing a Tsunami Warning System in the Caribbean

C. G. von Hillebrandt
Puerto Rico Seismic Network
Department of Geology UPR - Mayagüez

Thursday, June 30th, 2005

9:00 - 10:40 AM	Oral Session: Electron Transport/Modeling Session Chair: R. S. Craxton
10:40 - 11:00 AM	Coffee Break
11:00 - 12:20 PM	Oral Session: Direct-Drive/Hydrodynamics Session Chair: D. C. Wilson
12:20 - 1:00 PM	Business Meeting
7:30 - 8:30 PM	Evening Invited Talk Generation of High Quality Monoenergetic Electron Beams from Ultra-Intense Laser-Plasma Interaction J. Faure
8:30 - 11:00 PM	Evening Poster Session

Electron Transport/Modeling

Session Chair: R. S. Craxton

9:00 - 10:40 AM

Ablative Richtmyer–Meshkov Instability as a Test of Thermal Conduction Models Used in Hydrosimulations of ICF Experiments

V. N. Goncharov, O. V. Gotchev,
Laboratory for Laser Energetics, University of Rochester
250 East River Road, Rochester, NY 14623-1299

C. Cherfils-Clérouin
CEA-DIF, BP 12, 91680 Bruyères le Châtel, France

The perturbation evolution during the shock transit time is sensitive to the condition in the plasma corona created in inertial confinement fusion (ICF) experiments. Modes localized inside the conduction zone between the ablation front and the laser absorption region are shown to be stable and experience oscillatory behavior.[1] The period and decay rate of such oscillations depends on the ablation velocity, density scale length, and the effective index for thermal conduction. Modes with a wavelength larger than the conduction zone size, on the other hand, are unstable and grow during shock transit. The size of the conduction zone depends on the thermal conduction models in the hot plasma corona. To test the modeling, a series of ablative Ritchmyer–Meshkov instability experiments has been conducted on the OMEGA laser system. Comparison of the experimental results with hydrosimulation results leads to a specific choice of heat conduction model.

This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC52-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

1. A. L. Velikovich *et al.*, Phys. Plasmas 5, 1491 (1998); V. N. Goncharov, Phys. Rev. Lett. **82**, 2091 (1999); Y. Aglitskiy *et al.*, Phys. Rev. Lett. **87**, 265001 (2001).

Electron Heat Transport in the Laser Field in Direct-Drive ICF Plasmas

A. V. Maximov

Laboratory for Laser Energetics, University of Rochester
250 East River Road, Rochester, NY 14623-1299

Electron heat transport is a major component of direct-drive inertial confinement fusion (ICF) physics. An accurate description of the electron heat transport is especially important in the region closest to the critical-density surface, where electron-density gradients are steep. In that region, the multiple incident laser beams are turned, and most of laser absorption takes place.

The effect of laser field profiles on the electron distribution function in the near-critical-density region is considered. Modifications in the electron distribution function are obtained by solving the kinetic equation for electrons with the Landau–Fokker–Planck collision integral.

The importance of these changes in electron distribution for the numerical modeling of direct-drive ICF experiments with Fokker–Planck codes[1,2] and with delocalization models[1,3] is discussed.

This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC52-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

1. E. M. Epperlein and R. W. Short, Phys. Fluids B **3**, 3092 (1991).
2. A. Sunahara *et al.*, Phys. Rev. Lett. **91**, 095003 (2003).
3. G. P. Schurtz *et al.*, Phys. Plasmas **9**, 4238 (2000).

Prefer oral presentation

RO3

Modelling of CPA Laser heated Solids with the Implicit PIC Code LSP

R G Evans
AWE Aldermaston and Imperial College, London

Abstract.

Modeling the transport of laser generated relativistic electrons in solids is difficult due to the disparate length and time scales of the almost collisionless 'hot' electrons and the 'cold' electrons in the solid. We have previously[1)] described the use of the implicit hybrid model LSP to model experimental observations of the heating of sold density material to temperatures above 500eV. In this work the laser is not described directly but is represented by an electron source with parameters chosen to agree with explicit PIC models and with experimental data.

Following on from this work we have examined the validity of the LSP calculations with injected electrons over a wider range of target materials and densities. The results are consistent with analytic models where these are applicable and lend confidence to the broad predictions of the model albeit with a sensitivity to the details of the location of the injection point and the effects of laser prepulse.

Recently we used LSP with an implicit PIC description of the laser plasma interaction so that the electrons are generated self-consistently and compare the results with the electron injection model and with explicit PIC modeling of the electron acceleration. The spatial location of the return current is different in the two cases and gives rise to enhanced lateral spreading of the electrons with the laser input. Correct treatment of the return current is an essential part of modeling the creation and transport of energetic electron by CPA lasers and further work is needed in LSP and other models to establish the validity and limitation of the present models.

This work is supported by the UK MoD

1) R G Evans et al, 2004 Anomalous Absorption Conference, to appear in Applied Physics Letters May 2005

Transition from periodic lattice to solid plasma in ultrashort pulse irradiation of metals

D. Fisher, Z. Henis, E. Luzon, M. Fraenkel, S. Pecker, S.Eliezer

Soreq NRC, Yavneh, Israel.

We study both theoretically and experimentally an interaction of an ultrashort (tens of fs) laser pulse with solid targets. We are attempting to uncover the details of a gradual transition in the electron behavior from that characteristic of an ordered solid to that characteristic of a strongly-coupled plasma, and to provide a quantitative account of the electron collision frequency, electron momentum relaxation rate, electron-ion coupling coefficient, and dielectric permittivity in the irradiated target before the onset of hydrodynamic expansion of the target surface layers. The gradual shift in electron properties from those of a metal to those of a plasma, in pure metal targets, is brought along by the following mechanisms: an increase in electron collision frequency, an electron impact ionization of core states, changes in band structure with increasing electron temperature, and an ultrafast melting. Relative importance of the above mechanisms varies greatly between individual metals. Both theoretical and experimental work is ongoing.

Thanks to: Z. Zinamon, S.I. Anisimov, J. Meyer-ter-Vehn.

Keywords: Ultrashort pulse interactions, laser radiation absorption, electron collisions, electron-ion coupling, metal to plasma transition.

- D. Fisher, M. Fraenkel, Z. Henis, E. Moshe, S. Eliezer, Phys. Rev. E **65**, 016409 (Dec. 2001)
- D. Fisher, M. Fraenkel, Z. Zinamon, Z. Henis, E. Moshe, Y. Horovitz, E. Luzon, S. Maman, S.Eliezer, to appear in Laser Part. Beams (2005).
- D. Fisher, Z. Henis, Z. Zinamon, to be submitted to Phys. Rev. B.

EOS and electrical conductivity of warm expanded aluminum

C. Blancard and G. Faussurier

Département de Physique Théorique et Appliquée, CEA/DAM Ile-de-France,
B.P. 12 - F-91680 Bruyères-le-Châtel, France

The electronic and ionic structures of warm expanded aluminum are determined self-consistently using an average-atom formalism SCAALP (Self-Consistent Approach for Astrophysical and Laboratory Plasmas) based on the finite-temperature density-functional theory and the Gibbs-Bogolyubov inequality. Various EOS data, such as internal energy, pressure, entropy, and sound speed, are calculated by numerical differentiation of the plasma Helmholtz free energy. The electronic electrical conductivity is obtained either from the Ziman approach or from the Kubo-Greenwood formula implemented in the CPMD (Car-Parrinello Molecular Dynamics) code, which is used as a post-processor of the SCAALP code. Numerical results and comparisons with experiments are presented and discussed.

Oral Session 8

Direct-Drive/Hydrodynamics

Session Chair: D. C. Wilson

11:00 - 12:20 PM

A new approach for calculating electronic pressure in plasmas

A. Bar-shalom[1,2] and J. Oreg[2]

[1]NRCN,P.O.Box 9001, Beer-Sheva, Israel

[2]Artep Inc.,Columbia, MD 21045, USA

Abstract

We present a new approach for calculating the electronic pressure in plasmas. This approach uses the relativistic virial theorem to express the pressure as a sum of the total energy (not it's derivative) and a local density term. We discuss the relation between the Virial pressure and the pressure obtained by direct numerical differentiation of the free energy. We show that the two pressure formulas can be combined, allowing energy calibration from first principles, to comply with the periodic table zero pressure density points and nearby densities. Results are presented in comparison with other calculations and experiments. In addition we discuss the particular case of zero pressure relativistic virial theorem. It is shown that for this special case i.e. for systems with no external forces, the total energy (that includes exact exchange with no approximation) is a simple explicit functional of a local density for all excited states.

Modeling of Nike Experiments on Acceleration of Planar Targets Stabilized with a Short Spike

N. Metzler,[a] A. L. Velikovich,[b] A. J. Schmitt,[b] J. H. Gardner,[c] and J. L. Weaver[b]

[a]*Science Applications International Corporation, McLean, VA 22150. Permanent address: NRCN, P. O. Box 9001, Beer Sheva, Israel*
[b]*Plasma Physics Division, Naval Research Laboratory, Washington, D.C. 20375*
[c]*LCP&FD, Naval Research Laboratory, Washington, D.C. 20375*

A short sub-ns laser pulse (spike), incident upon a target produces a decelerating shock wave and a rarefaction wave immediately behind it, shaping a density gradient. The following main (driving) pulse "rides" this graded density profile before the decaying spike shock wave breaks out at the rear surface of the target. The graded density profile governs the dynamics of the decelerating main shock wave that propagates through it, the resulting adiabat profile and the perturbation seeding during the shock transit. We have demonstrated how the deceleration of the ablation front following the shock wave helps suppress laser imprint in the target [1]. The RT-mitigating effect of the tailored adiabat profile produced in the target by the decelerating shock wave has been discussed in [2].

Planar geometry of the experiment offers a considerable advantage for testing of this stabilization concept: It makes possible continuous in time, high-resolution measurements of the perturbation evolution in the target [3]. We report the results of 2D numerical modeling used to design such experiments on Nike laser at NRL with its recently developed short-pulse capability [4]. We simulated the effect of spike on laser imprint on smooth planar targets and on the growth of perturbations imposed as single-mode ripples with $\lambda = 20$ or 30 μm on the irradiated surface of the targets. For all cases, delay of the onset and/or suppression of the rate of the mass perturbation growth due to the spike have been predicted. These manifestations of stabilization are robust and significant enough to be observable on Nike. We discuss the relative roles of the deceleration of the ablation front [1] and the adiabat shaping [2] in the observable stabilization for Nike experimental conditions.

Work supported by the U. S. Department of Energy and performed at the Naval Research Laboratory.

[1] Metzler *et al.*, Phys. Plasmas **9**, 5050 (2002); Phys. Plasmas **10**, 1897 (2003).
[2] V. Goncharov *et al.*, Phys. Plasmas **10**, 1906 (2003); J. Perkins *et al.*, Bull. Am. Phys. Soc. **47**, 101 (2002); K. Anderson, R. Betti, Phys. Plasmas **10**, 4448 (2003); **11**, 5 (2004).
[3] Y. Aglitskiy *et al.*, Phys. Rev. Lett. **87**, 265001, 265002 (2001); Phys. Plasmas **9**, 2264 (2002).
[4] J. L. Weaver *et al.*, Bull. Am. Phys. Soc. **49**(8), 125 (2004).

Oral session preferred.

Investigations of Accelerated Targets Stabilized by a Short Spike Prepulse at the Nike KrF Laser Facility

J. Weaver,[a] N. Metzler,[b] A. L. Velikovich,[a] J. Oh,[c] Y. Aglitskiy,[b] M. Karasik,[a] A. N. Mostovych,[d] V. Serlin,[a] J. Gardner,[e] S. Obenschain,[a] A. Schmitt[a]

[a]*Plasma Physics Division, Naval Research Laboratory, Washington, DC 20375*
[b]*Science Application International Corporation, McLean, VA 22150*
[c]*Research Support Instruments, Lanham, MD 20706*
[d]*Enterprise Sciences, College Park, MD 20903*
[e]*LCP & FD, Naval Research Laboratory, Washington, DC 20375*

The addition of a short duration, 'spike', prepulse to typical laser pulse shapes used for inertial confinement fusion experiments has demonstrated a reduction in the growth of hydrodynamic instabilities in accelerated targets. In theoretical[1] and experimental[2] studies, the spike prepulse leads to an improvement in target stability for both planar and spherical geometries. A central concept for this pulse shaping under investigation at NRL is the creation of a tailored density/adiabat profile which both reduces the initial seeds for, and decreases the growth rate of, the Rayleigh-Taylor instability. A spike prepulse capability was recently added to the Nike KrF laser facility to allow comparison of the growth rates of mass modulation for rippled planar targets driven with the standard laser pulse with a low intensity foot (3-4 ns duration 1-5% of main pulse intensity) to targets driven with a early time spike (300 ps FWHM pulse 1-10% of main pulse intensity) followed by only the main pulse. Time evolution of mass nonuniformity was observed via x-ray radiography using a monochromatic crystal imagining system.[3] Flat and rippled targets were driven with a 4 ns long main pulse at ~ 40 TW/cm^2. Two rippled wavelengths (20 μm and 30 μm) were used to demonstrate modulation growth from small initial amplitudes (0.25 μm and 0.5 μm peak-to-valley amplitude) to the highly nonlinear stage of Rayleigh-Taylor growth. Instability growth delay and/or suppression were observed for the spike pulse shots compared to those with a low intensity foot. Decaying shock timing for the spike pulse was confirmed with a newly commissioned VISAR diagnostic. The propagation velocity of the decaying shock from the spike pulse was in good agreement with analytical predictions.[4]

Work supported by DoE and DoD

[1] N. Metzler *et al.*, Phys. Plasmas **9**, 5050 (2002); Phys. Plasmas **10**, 1897 (2003). V. Goncharov *et al.*, Phys. Plasmas **10**, 1906 (2003); A Schmitt *et al.*, Phys. Plasmas **11** 2716 (2004); K. Anderson, R. Betti, Phys. Plasmas **10**, 4448 (2003); **11,** 5 (2004); T. Collins, S. Skupsky, Phys. Plasmas **9**, 275, (2002).
[2] J. Knauer *et al.*, Phys. Plasmas **12**, 056306 (2005); T. Collins *et al.*, Phys. Plasmas **11**, 1569 (2004).
[3] Y. Aglitskiy *et al.*, Phys. Rev. Lett. **87**, 265001, 265001 (2001); Phys. Plasmas **9**, 2264 (2002).
[4] A. Velikovich *et al.*, Phys. Plasmas **10**, 3270 (2003).

RO9

Techniques for enabling late-time simulations of ICF target configurations

A. E. Koniges, R. W. Anderson, P. Wang,
B. T. N. Gunney, N. Elliot, D. C. Eder
(koniges@llnl.gov)
Lawrence Livermore National Laboratory
L-561, P. O. Box 808, Livermore, CA 94551
925-423-7890, FAX 925-423-2993

Arbitrary Lagrangian Eulerian (ALE) methods are extremely useful for problems involving motion over length scales large compared with internal scales. However, calculations of real problems can run into difficulty with mesh tangling, excessive computer time, or loss of accuracy. We use an air mesh technique for dealing with a variety of geometries and boundary conditions. Adaptive mesh refinement (AMR) can also help to improve accuracy while reducing the need for redundant calculations in a structured air mesh. We discuss the development of a combined ALE-AMR scheme that allows efficient representation of discrete objects in the air mesh calculation. These methods are applied to several different ICF target configurations including experiments already completed and those planned. Particular attention is paid to effects of the target components on diagnostics and the surrounding optics.

UCRL-ABS-211826

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

Evening Invited Talk 3

Generation of High Quality Monoenergetic Electron Beams from Ultra-Intense Laser-Plasma Interaction

J. Faure

7:30 - 8:30 PM

Generation of high quality monoenergetic electron beams from ultra-intense laser-plasma interaction

[1]J. Faure, [1]Y. Glinec, [1]V. Malka, [1]J. Santos, [1]F. Burgy, [2]T. Hosokai, [3]A. Pukhov, [3]S. Kiselev, [3]S. Gordienko

1. Laboratoire d'Optique Appliquée, Ecole Polytechnique-ENSTA, Palaiseau, France
2. Nuclear Engineering Research Laboratory, University of Tokyo, Tokai, Japan
3. *Institut fur Theoretische Physik, I, Heinrich-Heine-Universitat Duesseldorf, Duesseldorf, Germany*

We report on the production of high quality electron beams from the interaction of ultra-short and ultra-intense laser pulses with underdense plasmas [1]. We found a regime where the electron energy distribution is strongly non thermal: when the laser pulse spatial dimensions are comparable to the plasma wavelength, the ponderomotive force creates a cavity behind the laser pulse. Trapping and acceleration in this cavity results in a high quality electron beam with a quasi-monoenergetic energy distribution and a very low divergence of less than 10 mrad. This is the first time that a particle beam obtained from a plasma exhibits qualities which make it comparable to beams from conventional accelerators.
We will present experimental results showing how the quality of the electron beam depends strongly on laser and plasma parameters such as pulse duration, pulse radius, plasma density. In addition, using transition radiation as a diagnostic for ultrashort electron bunches, we obtained evidence that the electron bunches are shorter than 30 fs. 177MeV e^-'s
Finally, we will discuss some applications currently being investigated, such as gamma radiography [2] and water radiolysis. These applications make use of the unique characteristics of laser-plasma accelerators: small source size and short bunch duration.
These results are encouraging for all applications of table-top electron sources and X-ray sources.

27

[1] J. Faure *et al.*, A Laser-Plasma Accelerator Producing Monoenergetic Electron Beams, *Nature* **431**, 541 (2004)
[2] Y. Glinec *et al.*, High-Resolution γ-Ray Radiography Produced by a Laser-Plasma Driven Electron Source, *Phys. Rev. Lett.* **94**, 025003 (2005)

Evening Poster Session 3

8:30 - 11:00 PM

35th Annual Anomalous Absorption Conference
June 26 - July 1, 2005
Wyndham El Conquistador Resort
1000 El Conquistador Avenue
Fajardo, Puerto Rico

Pellet Core Heating via High Harmonic Electron Bernstein Modes in Fast Ignition Laser Fusion*

V. Stefan

Tesla Laboratories
The Stefan University
1010 Pearl Street, P. O. Box 2946
La Jolla, CA 92038

The bulk and tail plasma heating in fusion pellet core via nonlinear dissipation of high-harmonic Electron Bernstein Modes are studied.

The additional bulk plasma heating is realized through excitation of high harmonic Electron Bernstein, (EB), Modes by ignition - cone guided[1] - laser beam. In case of high group velocities – short wavelength excitations - EB Modes with $k_{II} = 0$ (k_{II} - wave vector along the B-Field) propagate to the core of the pellet whereby they are collisionaly dissipated leading to a bulk plasma heating. For EB Modes with finite k_{II} the tail plasma heating takes place with generation of suprathermal electrons in the pellet core.

The high harmonic EB Modes can be also excited by implosion-laser-beams if appropriate geometry of interaction is provided. In this case EB Modes are generated on the absorption surface and propagate to the core of the pellet. If implosion velocity and group velocity of EB Modes are made comparable (longer wavelength EB Modes) a simultaneous implosion-heating of the fusioń pellet takes place.

* Supported by Tesla Laboratories, La Jolla, CA 92038-2946.

1. M. Tabak, J. Hammer, M.E. Glinsky, W.L. Kruer, S. C. Wilks, J. Woodworth, E. M. Campbell, and M.D. Perry, Phys. Plasmas 1 (5), 1626 (1994).

35th Annual Anomalous Absorption Conference
June 26 - July 1, 2005
Wyndham El Conquistador Resort
1000 El Conquistador Avenue
Fajardo, Puerto Rico

Quasi-Stationary B-Fields Generation due to Weibel Instability in Fast Ignition Laser Fusion Pellets*

V. Stefan

Tesla Laboratories
The Stefan University
1010 Pearl Street, P. O. Box 2946
La Jolla, CA 92038

A novel effect of B-fields generation in laser-plasma interaction due to the Wiebel Instability[1] is studied. The low-frequency Weibel Modes are driven by a relativistic - suprathermal -electron beam in the presence of ignition laser radiation.

The quasi-stationary electric field of Weibel modes induces current in plasma, which in turn, generates quasi-stationary - d.c. B-Fields. For the relatively long wavelength Weibel Modes the self-pinching overcomes the magnetic pressure and d.c. B-Fields grow. In the presence of high-intensity laser radiation ($I_0 \leq 10^{20}$ W/cm^2) super strong (> 10 MG) B-Fields are generated.

The growth and saturation of B-Fields is analyzed under the conditions of normal skin effect in plasma. It is assumed that the wavelengths of Weibel Modes are much shorter than the plasma inhomogeneity scale length. The influence of the generated d.c. B-Fields on the electron transport is studied based on the electron mean-free-path in the presence of saturated B-Fields, evaluated for different sets of laser-plasma parameters. The study is done for both subcritical and supercritical plasmas.

* Supported by Tesla Laboratories, La Jolla, CA 92038-2946.

1. E. S. Weibel, Phys. Rev. Lett., 2,83 (1959)

35th Annual Anomalous Absorption Conference
Fajardo, Puerto Rico
June 27 – July 1, 2005

RP3

Features of the ANTHEM Code for Fast Ignition

R. J. Mason†

Applied Physics Division, Los Alamos National Laboratory, Los Alamos, NM 87545

ANTHEM[1] is a 2D implicit/hybrid simulation code. Its present form results from full time LDRD support since FY03. It is written in FORTRAN 95 with modules, and compiles on both PCs and the LANL Q Machines. ANTHEM has a grid following laser deposition package that can absorb light energy as inverse-bremsstrahlung, dump a fraction of this energy in a selected relativistic, hot-electron distribution near critical, and reflect the remainder, much as in a conventional hydro-simulation model. ANTHEM treats the hybrid background plasma as a relativisitic Eulerian fluid, allowing smooth density variations over seven orders of magnitude. For short pulse laser illumination, the code readily converts the background cold electron fluid into relativistic (PIC) particles, or into an alternate a relativistic hot fluid, while conserving net charge. ANTHEM uses a reliably convergent Implicit Moment electromagnetic field algorithm. Hot electron collisions and drag are included, as is cold, capped (at a minimum temperature) Spitzer resistivity. PIC particle background ions can be used for fast ion launching studies.

The PC version operates in the Visual Studio .Net 2003 environment with an Intel 8.1 Fortran compiler, allowing Open-MP parallelism. Graphical output is rendered via IDL. User Input is delivered via simple NAMELISTS. Both the physics and graphics algorithms are readily modified by code uses. Debugging is facilitated by colored, topographical, local-run renderings of the 2D code arrays with the Intel Array Visualizer. Picosecond duration runs employing 50K hot electron particles with a 200 x 200 cell mesh take several hours on a single 2.0 GHz Xeon processor. For many studies 0.5 μm size cells have proven sufficient. Implicitness permits the exploration of super-compressed targets for Fast Ignition.

†Also at the Research Applications Corporation, Los Alamos, NM
Email: mason@lanl.gov, rodmason01@msn.com
Tel: (505)-667-5524, (505)-672-1938; FAX: (505)-665-7725, (505)-672-0058

1. R. J. Mason and C. W. Cranfill, IEEE Trans. Plasma Sci. **PS-14**, 45 (1986); R. J. Mason, J. Comp. Phys. **71**, 429 (1987).

*Work supported by the USDOE.

Preference: Poster Presentation

Nonlocal Electron Transport in Laser-Produced Plasmas

Atsushi Sunahara[1], and Kunioki Mima[2]

[1] Institute for Laser Technology, Japan
2-6 Yamadaoka Suita Osaka Japan 565-0871
[2] Institute of Laser Engineering, Osaka University
2-6 Yamadaoka Suita Osaka Japan 565-0871

E-mail: suna@ile.osaka-u.ac.jp

Electron transport can play an important role in the laser ablation process in laser-produced plasma such as laser fusion plasma, where the absorbed laser energy is transferred from the laser absorption layer to the highly dense ablation region by electrons. In order to simulate the laser implosion process, accurate estimation of the electron transport is essential. The electron transport in the laser-produced plasma shows non-local properties, since the electron temperature can be increased locally due to the local laser energy deposition, and the electron mean free path may become comparable to the electron temperature scale length. In this condition, the electron velocity distribution function deviates from the Maxwell distribution function, and the Spitzer-Harm (SH) model becomes invalid since it assumes the Maxwellian distribution function. It overestimates the electron heat conduction. To correct the over-estimation of the electron conduction, the flux-limiter f_L is introduced, where the electron energy flux q_e is limited by ($f_L\, q_{FS}$). q_{FS} is the free-streaming energy flux defined as the $q_{FS} = nT_e v_{th}$ where n, T_e, v_{th} is the electron density, the electron temperature, and thermal velocity, respectively. This flux-limited SH model is widely used for the simulation of the electron thermal conduction in the plasma. However, the flux-limiter f_L is the free and empirical parameter, to be chosen properly for each problem. In order to calculate the electron transport for various conditions without the free-parameter, the time- and spatial evolution of the electron velocity distribution function should be solved based on the Fokker-Planck (FP) equation. We have developed the FP code to simulate the non-local electron transport in laser-produced plasmas. Earlier, we combined 1-D FP code with the 1D implosion simulation code, and successfully calculated the non-local electron transport in the laser implosion process. However, FP calculation is very time consuming and, especially in the multi-dimensional calculation, the computation time is a critical issue. Thus, the faster and robust FP code is needed. We have developed a two-dimensional Fokker-Planck code by using the directional operator splitting method and a high order advection scheme. Fokker-Planck equation is reduced to the advection form by diagonalization of the matrix of the system equations for the Legendre polynomial components f_0 and f_1 of the electron distribution function. We will describe the numerical scheme and present our results.

1) presenter

Poster

Models of Electron Transport in Laser Produced Plasmas

Denis Colombant, Code 6790 NRL, Wallace Manheimer, RSI

This paper examines five different models of electron thermal transport in laser produced spherical implosions. These are classical, classical with a flux limit f, delocalization[1], beam deposition [2], and Fokker-Planck solutions. The models are applied to two different laser plasma configurations, the recent University of Rochester cryogenic deuterium targets [3] (small target), and the NRL model of a direct drive DT laser fusion pellet driven by a Megajoule class KrF laser [4] (large target). In the small target, the results, i.e. bang time, neutron emission, and laser absorption are strongly dependent of f for flux limit models. Here small f's generate very steep temperature gradients, with the temperature gradient scale length always much less than the mean free path of the energy carrying electrons. The large target invokes the flux limits less, and as a result, the parameters of the fusion burn are much less dependent on the value of the flux limit, with classical thermal conductivity giving the same results as nearly any reasonable flux limit. Delocalization models are characterized by large preheat in the center of the target. For the larger fusion pellets, this is the only transport model which gives virtually no gain for a large target. The beam deposition model has characteristics of a flux limit in that it slows down the heat pulse propagation, but less so than most flux limits. Hence in the Rochester experiment, it does retard the bang time as compared to classical, but the experiment shows a greater delay. Also it does not steepen the temperature profile and it does allows for preheat. In most of the runs we have made, the beam deposition model does not differ greatly from the classical results, and for large pellets, it gives the same gain as classical or flux limited calculations. For Fokker Planck, we have used the published results, principally from Ref. [3] and have used it as a point of comparison for the other models. Fokker Planck results are not yet available for the large target.

1. E.M.Epperlein and R.W.Short, Phys. Fluids B 3, 3092 (1991)
2. W.Manheimer and D.Colombant, Phys. Plasmas, 11, 260 (2004)
3. A. Sunahara at al, Phys. Rev. Lett., 91, 095003, (2003)
4. S. Bodner, D. Colombant, A Schmitt, an M. Klapisch, Phys. Plasmas, 7, 2298, (2000)

Electron lateral transport and surface field generation by oblique incident laser pulse

Tatsufum Nakamura, Hitoshi Sakagami[1], Kunioki Kima,
Tomoyuki Johzaki, and Hideo Nagatomo

Institute of Laser Engineering, Osaka University, 2-6 Yamadaoka, Suita, Japan 565-0871
1) National Institute of Fusion Science, 322-6 Oroshicyo, Toki, Gifu, Japan 509-5292

The ultra-intense laser pulse interactions with solid target have been widelyinvestigated in relation with fast ignition, high energy electron and proton acceleration,and so on. In particular, it has attracted attentions that high density multi-mega eV electrons are gener ated to induce very strong quasi-static magnetic fields on a target surface. The generation mechanisms of magnetic field by laser-plasma interaction have been studied by m any authors. In collisional plasmas, magnetic fields are generated due to thermo-electric effects or instabilities by releasing the plasma free energy associating with electron momentum anisotropy exerted by strong laser heating. Other collisionless mechanisms are due to i) momentum transfer from the laser pulse to electrons, and ii) angular momentum transfer from circularly polarized laser pulse to electrons.

Recently electron transport in lateral direction on the target was observed in experiments of intense laser-matter interaction with oblique incidence [1,2]. Hot electrons are dominantly transported along the target surface than into the target. Similar phenomena are seen in 3D-PIC simulation of cone-laser interaction for fast ignition where hot electrons are guided and transported towards the tip of the cone by self-generated static magnetic field [3]. The generation mechanism of surface magnetic field and current layer formation is explained as to be a quasi-steady state of open system where absorbed laser energy is transported by the surface current [4].

In this research, we perform 2D PIC simulation on intense laser irradiation onto solid target. It is observed that the structure of surface current and quasi-static electro-magnetic field depend on the laser incident angle. In normal or small incident angle case, the amplitude of the surface magnetic field is quite small and accelerated electros mainly penetrate into the target. As the incident angle becomes large, the surface magnetic field becomes large and hot electrons flow along the target. The magnitude of the surface magnetic field becomes up to 30-40 percent of the laser magnetic field. The angular dependence of field structure and its role in energy absorption will be discussed in the meeting.

[1] T. Lin, et al., poster presentation in APS-DPP meeting in 2004.
[2] M . Downer, et al., in private communication.
[3] Y. Sentoku, et al., Phys. Plasmas 11, 3083 (2004).
[4] T. Nakamura, et al., Phys. Rev. Lett. 93, 265002 (2004).

Dispersion and transport of energetic particles created during the interaction of intense laser pulses with over dense plasma

J.C. Adam, A. Héron and G. Laval
Centre de Physique Théorique

Ecole Polytechnique-CNRS, 91128 Palaiseau (France)

We present a parametric study of the interaction of intense laser pulse of intensity varying from 10^{19}W/cm^2 up to 10^{21}W/cm^2 with plasma slabs of density ranging from 10 times critical up to 160 times critical. This study has been performed with the help of 2D and 3D PIC codes. Both types of simulations show the excitation of low frequency magnetic field at the plasma vacuum interface. The 2D and 3D results are extremely similar both in term of amplitude and spatial structures. We found more differences between two initial temperatures than between 2D and 3D simulations. Magnetic field inside the plasma is significantly larger in the asymptotic regime with an initial temperature of 1KeV rather than 10KeV. A diagnostic showing the angular dispersion of the particles as a function of their energy has been implemented. It shows that the magnetic layer deflects all the particles with energy lower than a few hundred KeV with an angle up to +/- 90°. Particles with higher energy have an initial dispersion of +/-25° that tends to increase later in time. Another diagnostic gives the distribution function of energy as a function of space. This diagnostic shows that a significant fraction of the current is carried by energetic particles.

We have modified the program to inject artificially a beam of energetic particles of a given energy spread in both longitudinal and transverse direction in order to simulate particles accelerated by the laser. Even if these particles are created in the middle of the plasma slab we observe the development of a thin layer of large static magnetic fields which immediately yields a transverse heating of the beam as in the laser case.

Particle simulation of ion acceleration from the interaction of Ultra-intense lasers with solid density targets

B. J. Albright, L. Yin, T. J. T. Kwan, K. J. Bowers,
B. M. Hegelich, and J. C. Fernandez

Los Alamos National Laboratory
Los Alamos, NM 87545 USA

When an intense short pulse laser impacts a thin, solid-density target, a highly collimated beam of fast ions may be produced from the rear target surface. Beams such as these have several characteristics which make them attractive for use in inertial confinement fusion, both for diagnostic applications and for fast-ignition. Recent experiments at the Trident facility at LANL have demonstrated for the first time the production of mono-energetic populations of laser-accelerated ions [1]. These ions were generated during the interaction of the Trident C (short pulse) beam with carefully prepared heterogeneous targets. Recently, we carried out computer simulations of such interaction using our newly developed particle-in-cell code VPIC [2]. VPIC is a fully electromagnetic relativistic three-dimensional explicit particle in cell simulation code in a massively parallel construct. For the field solve, it uses a domain-decomposed Yee-mesh explicit FDTD over super-hexahedral domains. The field solve accommodates tensor dielectrics and conductivities and magnetically permeable materials. Particles are advanced with a Boris leapfrog; current and force accumulation utilize a Villensor-Buneman algorithm. VPIC currently sustains approximately 9.3 million particle advances/second on the LANL ASC Lightning cluster. We will report on our 1D and 2D simulations, which compared favorably with those by Wilks et al. [3]. In addition, we will present comparisons between our simulations and the Trident experiments.

[1] B. M. Hegelich et al., submitted to *Nature*, 2005.
[2] Kevin J. Bowers, *Proceedings of 2003 International Conference on Nunerical Simulations of Plasmas, October 2003.*
[3] S. C. Wilks et al., *Phys. Plasmas* **8** 542 (2001)

35th Annual Anomalous Absorption Conference
Fajardo, Puerto Rico
June 27 – July 1, 2005

RP9

Modeling of Fast-Ion Production from Short-Pulse Laser-Matter Interactions

E. S. Dodd, K. Flippo, and R. J. Mason
Los Alamos National Laboratory

In recent years, the production of energetic ions from short-pulse interactions with thin foils has been of great interest. In addition to experiments, many theoretical and simulation-based studies have been pursued. Here we present simulation showing agreement between simulation and experiment for maximum energy and beam divergence of protons accelerated from both the front and rear surfaces of a thin aluminum foil. We show that the presence of plasma formed from laser-prepulse is necessary for acceleration of protons to multi-MeV energies from the front surface. A prepulse with a length of 1 ns and intensity of $\sim 10^{13}$ W/cm^2 was launched into a LASNEX simulations with aluminum foil thicknesses of 12.5 and 25 μm. The results were used to initialize particle-in-cell simulations (TRISTAN) where a short-pulse with 500 fs length and 2×10^{19} W/cm^2 was launched into the aluminum target, with and without the blow-off plasma. This work points to the importance of characterizing laser prepulse and plasma blow-off in short-pulse laser-matter interaction experiments.

* Supported under the U. S. Department of Energy by the University of California, Los Alamos National Laboratory under contract W-7405-ENG-36.

Poster presentation for the 35th Anomalous Absorption Conference

Integrated Absorption-Energy Transport Measurements from Ultra-intense Laser Heating of Atomic Clusters

A.S. Moore[1,2], E.T. Gumbrell[1,2], P. Nilson[2], J. Lazarus[2], E.L. Clark[1], R.M. Stevenson[1], R.A. Smith[2]
1. Plasma Physics Dept., AWE plc, Aldermaston, Reading, Berkshire, RG7 4PR, United Kingdom
2. Blackett Laboratory, Imperial College, London, SW7 2BZ, United Kingdom

Atomic clusters are well-known for their high energy absorption efficiency (>90%) upon interaction with a high intensity laser pulse ($<10^{18}$ Wcm^{-2}). This is typically explained by the high local density within the cluster, together with the sub-wavelength size of individual clusters. To date, no energy absorption measurements have been performed with a laser of relativistic intensity.

We report the first absorption and energy transport measurements resulting from the irradiation of large (>20nm), high Z, atomic clusters with high energy (50 – 600J), relativistic laser pulses. The data, taken using the Vulcan PW laser, shows anomalously high absorption, in excess of 90% of the incident energy, at focussed intensities from 10^{19} - 10^{20}Wcm^{-2}. Time- and spaced- resolved interferometric probing measurements indicate the role played by laser pre-pulse, and show how the enhanced, localised absorption results in the launch of an ultrafast, radial ionisation front. To first-order these are cylindrical fronts that propagate with speeds of order 10^{7} ms^{-1}, sustained over tens of picoseconds, and without evidence for non local pre-cursors.

MeV electron spectrometer data are also presented, together with ion energy measurements, and in conjunction with detailed simulations from 1-D and 2-D hydrodynamics simulations, these help isolate key features of the absorption and energy transport mechanisms. In particular, simulations of individual nano-plasma explosions are used to investigate the mechanisms leading to enhanced absorption. For comparison, larger scale simulations of the bulk plasma dynamics over many picoseconds are used to examine the key regimes of energy transport.

Laser wakefield acceleration in the blowout or bubble regime: A path towards a TeV stage

W. Lu, M. Tzoufras, F.S. Tsung, C. Huang, C.Joshi, W.B.Mori
University of California at Los Angeles

L.O.Silva and R.Fonseca
IST Portugal

There has been much recent theoretical, computational, and experimental progress on accelerating electrons in plasma waves generated by short pulse lasers. Three-dimensional PIC simulations using OSIRIS [1] predicted that a 14TW laser propagating in a preformed channel could produce a 280 MeV mono-energetic electron beam. Three independent experimental teams [2,3,4] also observed ~100 MeV mono-energetic electron beams when ~10-25TW lasers were sent through mm's of plasma. We have performed a series of 3D PIC simulations using OSIRIS which provide a very consistent picture for how these beams are produced and which identified the key differences between each of these experiments. Furthermore, we have developed a theory for how intense lasers create multi-dimensional plasma wakefields in the so-called blowout or bubble regimes. We have also found a parameter space for which stable self-guiding of the laser is possible without the need for external guiding. Using our new theory and the self-guiding regime, we have derived a scaling law for the output energy of a laser wakefield accelerator (LWFA) stage, E~.5(Power/8.5GW)^1/3(ω_o/ω_p)^4/3. Based on this scaling law, we have recently simulated a 1GeV LWFA stage using a 200TW laser. And by extrapolating this forward, we believe it will be possible to make a 1TeV stage by propagating a 300PW, 1ps long laser pulse through 200 meters of a $2\times10^{15}cm^{-3}$ density plasma. In this poster, we will provide the assumptions that went into deriving our new scaling law and describe the physics inherent in LWFA in the blowout regime.

Work supported by DOE under grant nos. DE-FG03-92ER40727, DE-FG02-03NA00065, DE-FC02-01ER41179 and DE-FG02-ER54721

1. F.S.Tsung et al *Phys. Rev. Lett.*, **93**, p. 185002 (2004).
2. Mangles et al, *Nature*, **431**, p. 535 (2004).
3. Geddes et al., *Nature*, **431**, p. 538 (2004).
4. Fauve et al., *Nature*, **431**, p. 541 (2004).

Inflation Threshold II: Analytic Calculations and Application of Nonlinear Threshold for Enhanced Backward Raman Scattering Due to Trapping

B. Bezzerides**, D. F. DuBois**, H.X. Vu*
*University of California at San Diego
**Los Alamos National Laboratory

We present an analytical expression for a laser intensity threshold for rapid increase in the reflectivity from single hot spots (or speckles) due to backward, stimulated Raman scattering (BSRS) in the strong damping regime. The physical basis for the calculation is the observation in particle-in-cell simulations that the rapid increase occurs simultaneously with the onset of trapping in the convectively growing Langmuir wave (LW) of the BSRS. From linear theory we first calculate the LW amplitude growing from thermal (discrete particle) noise across the speckle length as a function of the laser intensity. We then calculate the rms diffusion velocity for electrons with mean velocity near the phase velocity of the LW in the presence of the fluctuating fields resulting from particle discreteness. Empirically the condition for onset is well represented when the trapping velocity in the LW exceeds the diffusion velocity in a bounce time. In addition to diffusion, particles can lose energy due to the drag force. It is shown that this effect does not alter the original condition. The onset condition is shown to correspond to a laser intensity less than the linear condition for absolute instability, thereby confirming that the inflation threshold is truly a nonlinear phenomena. Comparisons with reduced PIC (RPIC) were strictly 1D (including a model for sideloss where necessary). The straightforward generalization to 3D is presented where now the noise fluctuations are fully 3D. Noting that the condition for onset is fundamentally a condition on the spatially local amplitude of the LW, we propose a reduced fluid model in which the effects of trapping on Landau damping and frequency detuning are switched on or off throughout the computational box as the onset condition described above is applied to the local amplitude of the LW. Some calculations based on this model are presented and compared to results from RPIC.

For a poster presentation at the 35th Anomalous Absorption Conference, June27-1 (2005)
*Research supported by USDOE DOE Research Grant# DE-FG52-04NA0041/A000
And **DOE contract No. W-7495-Eng.36

Thomson scatter spectra from Ionospheric Excitation experiments and their relevance for forward SRS in laser-plasma interactions

Don DuBois*, H.X. Vu**, and B. Bezzerides*
*Los Alamos National Laboratory
* *University of California at San Diego

Forward stimulated Raman scattering (FSRS) is often found to be stronger than backward stimulated Raman scattering (BSRS), in PIC simulations [1], under high electron temperature, low density, regimes predicted by NIF target designs. Under these conditions the nonlinear saturation of FSRS is seen to proceed from the Langmuir decay instability (LDI) and related Langmuir cavitation processes. Ionospheric excitation experiments have excited the parametric decay instability (PDI) (and related instabilities) at the reflection altitude of a powerful HF wave. Thomson scatter spectra of fluctuations excited by these instabilities have verified in detail the predictions of reduced (extended "Zakharov") modeling of the nonlinear saturation of these instabilities. The results and interpretation of these experiments and models will be reviewed. Similarities and differences in how these saturation processes evolve from the two distinct instabilities (PDI and FSRS) will be discussed including the simulation [2] of backward SRS at low values of $k\lambda_D$ using reduced modeling. The necessity to resolve the LDI modes places some requirements on the numerical simulation models for FSRS that require further research. Some initial steps in this direction using reduced particle –in- cell simulations (RPIC) will be reviewed. Preliminary 2D simulation results for FSRS from single laser hot spots, under NIF related conditions, will be discussed. Some of the background for this subject will be discussed in an earlier oral presentation.

[1] H.X.Vu, D.F.DuBois, and B.Bezzerides, Phys.Rev.Lett.**86**,4306(2001); PoP**9**,1745(2003)
[2] D.A. Russell, D.F. DuBois, and H.A. Rose, Phys. Plasmas **6**, 1294 (1999)

For **a poster presentation** at the 35th Anomalous Absorption Conference, June 27-July 1 (2005)
Research Supported by *USDOE under contract No.W-7495-Eng.36 and *NSF Grant No.97-13563ATM and **USDOE DOE Research Grant# DE-FG52-04NA0041/A000.

Interplay of Electron Trapping and Inhomogeneity in Raman Scattering

David J. Strozzi[1], A. Bers[1], E. A. Williams[2], A. B. Langdon[2]
[1] *Massachusetts Institute of Technology, Cambridge, MA 02139*
[2] *Lawrence Livermore National Lab, Livermore, CA 94550*

We explore the role of electron trapping and plasma inhomogeneity in stimulated Raman scattering (SRS) with kinetic simulations and analytic theory. Recent experiments [1] show high levels of SRS even when $k\lambda_{De}$ of the SRS-generated plasma wave is high, and linear Landau damping should be large. The trapping of electrons in the potential well of the plasma wave strongly reduces Landau damping. This leads to greatly enhanced SRS in homogeneous plasmas, as has been shown in reduced PIC simulations [2]. In addition, the frequency of the plasma wave is nonlinearly down-shifted by trapping [3]. This can prevent the SRS wave frequencies from matching and can limit the scattering.

When the plasma is inhomogeneous, the variation of wavenumber with position detunes SRS away from the resonance point. Linearly, there is a steady state where SRS is a convective instability, and scattered light amplifies as it propagates across the interaction region. In such a boundary-value problem trapping introduces a nonlinear wavenumber shift rather than a frequency shift. The shift varies in space with the plasma wave amplitude. This can either reduce or enhance the detuning due to inhomogeneity.

We have developed a 1-D Eulerian Vlasov-Maxwell solver named ELVIS to study SRS [4]. For homogeneous plasmas, the code gives large increases in reflectivity over linear convective gain estimates. The reflectivity rises after several bounce periods of the trapped electrons, which is consistent with Landau damping reduction explaining the increase. When the plasma is inhomogeneous, the reflectivity depends strongly on the geometry of the problem; namely, whether the laser is propagating toward higher or lower density. When the laser propagates up the density gradient, the reflectivity can be well above the linear gain even when damping is neglected (for instance, due to trapping) [5]. The reflectivity may not be steady in time, and can display bursty behavior.

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

[1] J. Fernández, J. A. Cobble, et al., *Phys. Plasmas* **7**, 3743 (2000).
[2] H. X. Vu, D. F.DuBois, and B. Bezzerides, *Phys. Rev. Lett.* **86**, 4306 (2001).
[3] G. J. Morales and T. M. O'Neil, *Phys. Rev. Lett.* **28**, 417 (1972).
[4] D. J. Strozzi, M. M. Shoucri, and A. Bers, *Comput. Phys. Comm.* **164**, 1656 (2004).
[5] M. N. Rosenbluth, *Phys. Rev. Lett.* **29**, 565 (1972).

Development of an X-ray Diagnostic Raytrace Postprocessing Code for Unstructured ASC Codes

Greg Pollak and Bob Clark

Los Alamos National Laboratory
Los Alamos NM 87545

Many X-ray diagnostic postprocessing codes for Radiation-Hydrodymanics (Radhydro) simulations have been written over the years but these codes have generally structured meshes. In addition, these Radhydro codes were essentially never 3D, so the postprocessimg code need not be either. Recent Radhydro codes developed under the DOE ASC program almost always utilize unstructured meshes, and are always capable of 3D simulations. In addition, since there are several of these ASC codes now operational, and each must produce graphics dump files, a desirable feature of a new postprocessing code would be to utilize the graphics dumps as inputs to the postprocessing code. This would eliminate the need for postprocessor-specific new coding for each of the ASC codes. We report here on the development of a postprocessing code, call Plaspp, for at least 2 ASC codes, utilizing their dump files for either of 2 graphics dump formats as the inputs to the postprocessor. In principle, any ASC, or older2D, code which produces graphics in either of the 2 formats should be postprocesseable by Plasspp. Some applications of the code will be presented.

Friday, July1st, 2005

9:00 -	10:40 AM	Oral Session: LPI Session Chair: B. Afeyan
10:40 -	11:00 AM	Coffee Break
11:00 -	12:40 PM	Oral Session: NIF Session Chair: Y. Aglitskiy

Oral Session 9

Laser Plasma Interactions

Session Chair: B. Afeyan

9:00 - 10:40 AM

Microinstabilities of Relativistic Electron Beams in Plasmas

R. W. Short and J. Myatt

Laboratory for Laser Energetics, University of Rochester
250 East River Road, Rochester, NY 14623-1299

Many versions of the fast-ignitor (FI) concept for laser-driven inertial confinement fusion involve the propagation of an intense relativistic electron beam through a background plasma ranging from near-critical density to the compressed core density. Such beams can be disrupted by the growth of small-scale instabilities such as filamentation and the two-stream instability, which tend to develop faster than macroinstabilities such as kink and pinch instabilities. The growth of these microinstabilities results from background plasma impedance to the return current. This impedance is largely resistive (electron collisions) at high densities (e.g., resistive filamentation[1]) and inductive (electron inertia) at lower densities (e.g., Weibel[2]). In this presentation, a comprehensive dispersion relation for these instabilities is presented and its consequences explored for various ranges of plasma and beam parameters. The dispersion relation includes both electrostatic and electromagnetic terms, allows arbitrary directions and complex values for the perturbation wave vector, and can incorporate fully relativistic Maxwell–Boltzman–Jüttner distribution functions or approximations thereto. It can therefore be used to calculate spatial as well as temporal growth rates, to investigate both absolute and convective forms of the instabilities, and to determine the relative importance of electromagnetic (filamentation) and electrostatic (two-stream) instabilities, as well as mixed forms. The results should be useful in benchmarking and optimizing FI simulations using codes such as LSP.[3]

This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC52-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

1. L. Gremillet *et al.*, Phys. Plasmas **9**, 941 (2002).
2. E. S. Weibel, Phys. Rev. Lett. **2**, 83 (1959).
3. D. R. Welch *et al.*, Nucl. Instrum. Methods Phys. Res. A **464**, 134 (2001).

Scaling of laser interactions with plasmas from high-Z gasbags

R. L. Berger, C. Constantin, L. Divol, N. Meezan, C. Niemann, L.J. Suter

Lawrence Livermore National Laboratory

Gasbags filled with high-Z gases (Krypton and Xenon) illuminated with 38 heater beams of 351nm wavelength and two probe beams at the Omega Laser Facility showed remarkably little stimulated Brillouin backscatter and even less stimulated Raman backscatter of the 351nm and 527nm probe beams. The probe beams were focused with an f/6.7 lens to a 250 micron diameter spot near the center of the gasbag to produce a vacuum intensity of 8×10^{14} W/cm^2. The heater beams were focused 3.5 mm beyond the target center. Both the heater and probe beams were 1ns in duration but the probe beams were delayed 500ps with respect to the heater beams.

For the duration of the probe beam interaction with the plasma, the electron temperature at the center reaches 5keV for the lowest fill pressures ($N_e = 4 \times 10^{20}$ cm^{-3} where N_e is the electron density) and 3.5keV for the higher fill pressures ($N_e = 1 \times 10^{21}$ cm^{-3}). Because Z Te/Ti >> 1, ion acoustic waves driven by the SBS interaction are weakly damped, and expectations, based on experiments with CO_2 fills where Z Te/Ti is also large, are that SBS should exceed 25% rather than the measured 2-5%. With a combination of linear gain calculations and pF3d simulations, we show that the reflectivity can be explained by a combination of the effects of inverse bremsstrahlung absorption of the probe beam and the backscattered light, velocity and density gradients, and the large Debye length of the hot plasma.

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

pF3d Simulations of Smoothed Laser Beam Propagation Through NEL Gaspipes

M. R. Dorr, R. L. Berger, L. Divol, C. H. Still, E. A. Williams, D. H. Froula, S. H. Glenzer and O. S. Jones
Lawrence Livermore National Laboratory

We present pF3d simulations of NIF Early Light (NEL) propagation experiments. The goal of the experiments and these simulations was to determine better the beam smoothing requirements of the National Ignition Facility (NIF). A 15 kJ- 3.5 ns long laser pulse was shot through a 7mm long CO_2-filled gaspipe. A full aperture phase plate produced a 500-μm circular spot at best focus (at the center of the gaspipe), resulting in an average intensity of 2.3 x 10^{15} W/cm^2. The shot was repeated with the addition of polarization smoothing (PS) and smoothing by spectral dispersion (SSD). X-ray images showed that, without PS and SSD, the plasma was heated over a much wider area and shorter axial distance than predicted by LASNEX simulations. However, LASNEX simulations with Spitzer-Härm heat conduction agree well with the observed beam propagation (transverse soft X-ray images) for the shots using full beam smoothing (PS + SSD), once the measured backscatter has been subtracted from the incident energy.

The working hypothesis advanced to explain the data was that the addition of PS and SSD reduces filamentation-induced beam spray that would otherwise spread the beam energy over a larger area than the nominal beam spot, reducing the mean temperature and enhancing inverse bremsstrahlung absorption. By controlling filamentation, SSD and PS thus allowed the beam to propagate with the energy confined within a narrower transverse area, which increases the temperature and reduces the absorption compared with the RPP beam. The laser plasma interaction code pF3d was employed to investigate this hypothesis numerically, and the results of these simulations substantially support this picture.

Since the prediction of temperature within the beam involves the calculation of fluxes out of the directly heated area to the cold plasma surrounding the beam, a 3D conduction model was required which included the ability to simulate a sufficiently large volume around the beam as well. A fully 3D pF3d simulation of propagation in 7 mm of plasma for 3.5 ns exceeds the capability of even the largest available computers. A mixed 2D/3D approach was therefore adopted: the light propagation and hydrodynamic equations were solved in a 2D plane while heat conduction and energy deposition were done on a full 3D coarser grid (called the collar grid) that extends far beyond the laser beam. By assuming an axisymmetric beam, the 3D conduction source was obtained by rotating the 2D laser intensity about the symmetry axis. A dynamic renormalization of laser intensity was performed to account for beam spreading in the omitted third dimension.

In this talk, we present the results of our numerical simulations and comparisons with the experiment.

UCRL-ABS-211740
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

FO4

Reduction of backscatter in long plasma with beam smoothing in the moderate gain regime

L. Divol, E. A. Williams, R. L. Berger and D. Hinkel
Lawrence Livermore National Laboratory, USA.

In typical NIF ignition targets, the laser beams propagate through underdense regions many millimeters long. In large regions of these hot underdense plasmas, stimulated Brillouin and Raman scattering instabilities are in a strongly damped regime with linear amplification gains usually below 20 (for intensity). Under these conditions of long plasmas with moderate gains, phase conjugation can greatly enhance the simulated scattering processes by doubling the effective gain. We'll show that polarization smoothing and smoothing by spectral dispersion, as they reduce the beam contrast and coherence, can strongly reduce phase conjugation and thus lower the reflectivity. We'll quantitatively assess the effect for NIF parameters using an analytical approach (with a variational method) and fluid simulations of the backscattering using the laser plasma interaction code pF3d.

Oral presentation preferred

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

Laser Plasma Interactions in de-focussed laser beams.

E. A. Williams, A. B. Langdon and L. Divol.
Lawrence Livermore National Laboratory
Livermore, CA, USA 94550

In indirect drive ICF ignition designs, the laser energy is delivered into the hohlraum through the laser entrance holes (LEH), which are sized as small as practicable to minimize X-ray radiation losses. On the other hand, deleterious laser plasma processes, such as filamentation and stimulated backscatter, typically increase with laser intensity. Ideally, therefore, the laser spot shape should be a close fit to the LEH, with uniform (envelope) intensity in the spot and minimal energy at larger radii spilling onto the LEH material. This keeps the laser intensity as low as possible consistent with the area of the LEH aperture and the power requirements of the design.

This can be achieved (at least for apertures significantly larger than the laser's focal spot) by the use of custom-designed phase plates. However, outfitting the 192 beam NIF laser with multiple sets of phase plates optimized for a variety of different LEH aperture sizes is an expensive proposition. It is thus important to assess the impact on laser-plasma interaction processes of using phase plates with a smaller than optimum focal spot (or even no phase plates at all!) and de-focussing the beam to expand it to fill the LEH and lower its intensity.

We find significant effects both from the lack of uniformity of the laser envelope out of the focal plane, and from the changes in the characteristic sizes of the laser speckle. We quantify these effects with analytic estimates and simulations using our laser plasma interaction code pF3D.

Principal Author: E. A. Williams,
L-038, Lawrence Livermore National Laboratory
P.O. Box 808
Livermore, CA 94550
(925) 423-2626
williams16@llnl.gov

- Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract No. W-7405-ENG-48
- UCRL-ABS-211801

Oral Session 10

Oral Session: NIF
Session Chair: Y. Aglitskiy

11:00 - 12:40 PM

Temporal anti-correlation of SRS and SBS*

E. S. Dodd, B. Bezzerides, D. F. DuBois
Los Alamos National Laboratory

H. X. Vu
University of California, San Diego

For about 20 years experimental [1] and theoretical [2] evidence has accumulated showing the anti-correlation of SRS and SBS backscatter reflectivity levels. Using reduced particle-in-cell (RPIC) methods we study these instabilities in regimes where the nonlinear behavior is controlled by electron and ion trapping in the daughter electrostatic waves-Langmuir waves (LWs) and ion acoustic waves (IAWs), respectively. The time behavior is characterized by bursts of several sub-picosecond SRS reflectivity pulses, alternating with single multi-ps pulses of SBS. SRS is observed to die as soon as SBS begins to grow from low levels. The temporal envelope of the SRS LW obeys a Schrödinger equation where, for this problem, the "potential" is the periodic electron density fluctuation, δn_{IAW}, resulting from the SBS IAW [2]. The LWs in this case have a "Bloch wave" structure with a distorted frequency dispersion, including frequency band gaps at $k_{LW}{\sim}k_{IAW}/2{\sim}k_{laser}$. This band structure is observed in RPIC ω, k spectra of the LWs, which is functionally equivalent to experimental Thomson scatter spectra. The frequency distortion increases as δn_{IAW} increases in time, resulting in a time dependent frequency shift of the LW that detunes SRS. A static IAW, resulting in a static frequency shift, is found to be less effective in reducing SRS. This anti correlation physics may explain the observed dependence of the SRS reflectivity on the ion acoustic damping [3] in regimes where saturation via the Langmuir decay instability is not expected. Simulations in laser and plasma parameter regimes typical of NIF targets and for Trident single hot spot experiments show similar behavior. This work can lead to a model of the SRS-SBS coupling for macroscopic simulations such as pF3d.

[1] C. J. Walsh, D. M. Villeneuve, and H. A. Baldis, *Phys.Rev. Lett.* **53,** 1445 (1984); D. M. Villeneuve, H. A. Baldis and J. E. Bernard, *Phys.Rev. Lett.* **59,** 1585 (1987).
[2] H. A. Rose, D.F. DuBois, and B. Bezzerides, *Phys. Rev. Lett.* **58**, 2547 (1987); G. Bonnaud, D. Pesme and R. Pellat, *Phys. Fluids B* **2**, 1618 (1990).
[3] J. C. Fernández, *et al.*, *Phys. Rev. Lett.* 77, 2702 (1996); R. K. Kirkwood, *et al.*, *Phys. Rev. Lett.* 77, 2706 (1996);

* Supported under the U. S. Department of Energy by the University of California, Los Alamos National Laboratory under contract W-7405-ENG-36.

Oral presentation for the 35th Anomalous Absorption Conference

Inflation Threshold: A Nonlinear Threshold for Enhanced Backward Raman Scattering Due to Trapping

H.X. Vu*, B. Bezzerides**, and D.F. DuBois**
University of California at San Diego
** Los Alamos National Laboratory

Particle-in-cell simulations [1][2][3] of backward, stimulated Raman scattering, (BSRS) from single hot spots (or speckles) have shown a laser intensity threshold for the rapid increase in the reflectivity. A similar rapid onset of BSRS reflectivity was observed in single hot spot experiments at the Trident laser [4]. A theory of this rapid onset is presented here: The BSRS Langmuir wave (LW) grows from thermal (discrete particle) noise by linear parametric convective amplification until its amplitude at any given spatial location exceeds a threshold condition for the trapping of electrons. The LW threshold amplitude is fixed when the coherent trapping velocity of electrons in the LW (depending on the LW amplitude) exceeds the rms diffusion velocity, accumulated in one bounce time, for electrons with mean velocities near the phase velocity of the LW. The diffusion arises from field fluctuations, resulting from particle discreteness, that contribute to electron-electron collisions. The laser thresholds calculated from this condition, using the kinetic theory appropriate to a 1D particle-in-cell simulation, closely approximate those observed in 1D reduced PIC (RPIC) simulations (some including side loss of trapped electrons from speckles) for a wide range of laser and plasma conditions. The local LW condition is easily extended to 3D. In the presence of strong Landau damping, below the threshold, it is observed in the simulations that the BSRS reflectivity grows by linear convection, consistent with analytical estimates. At and above the threshold intensity the RPIC reflectivity increases dramatically above the linear convection predictions due to the onset of trapping which reduces the Landau damping of the LW. The inflation threshold is a completely nonlinear phenomenon since it always occurs below the linearly-predicted, absolute instability thresholds, justifying the name "trapping inflation threshold". Saturation of the reflectivity above the inflation threshold results from frequency detuning due to the trapping-induced frequency shift of the LW [5]. The detailed behavior also depends on the self consistently modified electron velocity distribution [3]. The a priori estimates of the local inflation threshold presented here may be applicable to large scale modeling codes such as pf3D. Preliminary investigation of a three-wave envelope model including these local in space inflation thresholds for the LWs will be presented with the objective of reproducing the RPIC observations.

[1] H.X. Vu , D.F. DuBois, and B. Bezzerides, Phys. Plasmas.**9**, 1745 (2002).
[2 D.F. DuBois, H.X. Vu , and B. Bezzerides, at the Workshop on SRS/SBS Saturation Livermore, CA, April 3-5 ,2002
[3] L.Yin *et al,* Phys. Rev. Lett., submitted (2004).
[4] D.S. Montgomery , Laser and Particle Beams **17** , 349 (1999);
[5] H.X. Vu , D.F. DuBois, and B. Bezzerides, Phys. Rev. Lett. **86**, 4306 (2001).

For **oral presentation** at the 35th Anomalous Absorption Conference, June 27-29 (2005)

Research Supported by *USDOE DOE Research Grant# DE-FG52-04NA0041/A000 and **DOE contract No.W-7495-Eng.36 .

Recent evidence for increased radiation drive in U:Au:Dy cocktail hohlraums*

O. S. Jones, J. Schein, M. D. Rosen, L. J. Suter, R. J. Wallace, J. Gunther, and K. M. Campbell
Lawrence Livermore National Laboratory
Livermore, CA, USA 94550

Although standard gold hohlraums have proven to be effective for generating and confining soft x-rays for indirect drive ICF experiments, it is theoretically possible to make hohlraums more efficient by using mixtures of materials, known as "cocktails". Calculations show that by suitably choosing a mixture of two or three materials, one can reduce the radiation energy lost into the hohlraum wall by simultaneously increasing the opacity and decreasing the heat capacity of the wall material relative to a pure gold wall. Previous calculations for a 250 eV peak radiation temperature ignition drive profile using the STA opacity model have shown that a mixture of 60% (atomic fraction) uranium, 20% gold, and 20% dysprosium was nearly optimal.

We report on recent experiments done at Omega in which we measured the radiation drive of cocktail and gold hohlraums with a filtered x-ray diode array (Dante). The hohlraums were heated by a 1 ns, 20 kJ laser pulse and reached a peak radiation temperature of approximately 270 eV. The hohlraums were made by co-sputtering 2 microns of the U:Au:Dy mixture onto the inside of half of a gold hohlraum, which was then glued together. This unusual construction technique was an attempt to minimize the oxygen contamination that could potentially occur if the cocktail layer were deposited on the outside of a mandrel that is then leached away (the way previously tested cocktail hohlraums were constructed). The oxygen content of these cocktails was measured and taken into account in our calculations. The thermal portion (0-2 keV) of the radiation escaping through the laser entrance hole was found to be about 3 eV hotter for the cocktail hohlraums than for the gold hohlraums. This is in fair agreement with calculations when all potential sources of radiation leakage out of the hohlraum are accounted for.

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

FO9

Damage Mitigation on NIF using Shields and Target Redesign

D. C. Eder, P. K. Whitman, A. E. Koniges, R. W. Anderson, P. Wang, B. T. Gunney, T. G. Parham, J. G. Koerner, S. N. Dixit, T. I. Suratwala, B. E. Blue, J. F. Hansen, M. T. Tobin, H. F. Robey, M. L. Spaeth, and B. J. MacGowan

(deder@llnl.gov)
Lawrence Livermore National Laboratory
L-463, P. O. Box 808, Livermore, CA 94551
925-423-3483, FAX 925-422-8395

For experimental campaigns on the National Ignition Facility (NIF) to be successful, they must obtain useful data without causing unacceptable damage to optics and diagnostic components. There are 192 fused silica main debris shields (MDS) exposed to the potentially hostile target chamber environment on each shot. Damage in these optics results either from the interaction of laser light with contamination and pre-existing imperfections on the optic surface or from the impact of shrapnel fragments. Mitigation of this second damage source is possible by identifying shrapnel sources and shielding optics from them. It was recently demonstrated that the addition of 1.1-mm thick borosilicate disposable debris shields (DDS) block the majority of debris and shrapnel fragments from reaching the relatively expensive MDS's. However, DDS's cannot stop large, faster moving fragments. We discuss our ability to predict the number of these damaging fragments. In addition to using shields, we can also redesign targets to reduce their impact. One technique is to change the orientation of a source of shrapnel to direct fragments away from a given component. We have experimentally demonstrated this mitigation technique in this case of a Ta pinhole array damaging a detector. Another mitigation technique is to change the source material to one that produces smaller fragments. Successful of these mitigation techniques require knowledge of the size, velocity, and spatial distribution of shrapnel fragments from complex target-diagnostic configurations. We discuss the status of our 3D modeling effort and what is require to simulate NIF ignition targets.

UCRL-ABS-211607

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

35th Annual Anomalous Absorption Conference
Fajardo, Puerto Rico
June 27 to July 1, 2005

FO10

2ω beam propagation in large-scale length plasmas at NIF like temperatures*

C. Niemann[1], L. Divol[1], D.H. Froula[1], G. Gregori[1], O. Jones[1], R.K. Kirkwood[1], J.D. Moody[1], J.S. Ross[1], C. Sorce[1], R. Bahr[2], and S.H. Glenzer[1]

[1]*Lawrence Livermore National Laboratory, 7000 East Avenue, Livermore, CA 94550*
[2]*Laboratory for Laser Energetics, 250 E. River Road, Rochester, NY 14623*

We have measured the propagation and backscatter of a 2ω (527 nm) high intensity (~$5x10^{14}$ W/cm^2) interaction beam through large-scale length plasmas at NIF like temperatures of up to 4 keV. The experiments were performed at the Omega laser facility using the 2ω transmitted beam diagnostic (TBD). The large scale length plasma is created by heating 2 mm x 1.6 mm diam. hohlraum targets with 36 defocused heater beams at 3ω, delivering a total energy of 16 kJ in a 1 ns square pulse. We assessed beam propagation both in gas-filled and in foam-filled targets at 2ω NIF design densities around n_e/n_c=5% (at 3w). We observe a beam transmission as high as 80% with negligible SRS reflectivity and modest levels of SBS. Both 2ω and 3ω SBS spectra are consistent with a plasma temperature above 3.5 keV, which is a factor of two higher than the temperatures in gasbag-plasmas that were studied previously.

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

List of Early Conference Registrants

Name	Organization	Email Address
Dimitri Fisher	Soreq NRC	dimitrifisher@yahoo.com
Zohar Henis	Soreq NRC	henis@soreq.gov.il
Marcel Klapisch	ARTEP, Inc.	klapisch@this.nrl.navy.mil
Thomas Fouquet	CENTER OF THEORETICAL PHYSICS at Ecole Polytechnique	fouquet@cpht.polytechnique.fr
Peter Amendt	Lawrence Livermore National Laboratory	amendt1@llnl.gov
Frederic Blasco	Université Bordeaux 1	blasco@celia.u-bordeaux1.fr
Jerome Faure	LOA	jerome.faure@ensta.fr
Bedros Afeyan	Polymath Research Inc.	bedros@polymath-usa.com
David Strozzi	MIT	DSTROZZI@MIT.EDU
Hiroshi Azechi	Institute of Laser Engineering, Osaka University	azechi@ile.osaka-u.ac.jp
Carl Schroeder	Lawrence Berkeley National Laboratory	CBSchroeder@lbl.gov
B. Hegelich	Los Alamos National Laboratory	hegelich@lanl.gov
Eric Esarey	Lawrence Berkeley National Laboratory	EHEsarey@lbl.gov
Michel Busquet	ARTEP, Inc.	busquet@this.nrl.navy.mil
Harvey Rose	Los Alamos National Laboratory	har@lanl.gov
Pascal Loiseau	CEA	pascal.loiseau@cea.fr
Paul-edouard Masson-laborde	CEA	pemasson@hotmail.com
Michel Casanova	CEA	michel.casanova@cea.fr
Olivier Larroche	CEA	olivier.larroche@cea.fr
Valeri Goncharov	Laboratory for Laser Energetics, University of Rochester	vgon@lle.rochester.edu
Reuben Epstein	Laboratory for Laser Energetics, University of Rochester	reps@lle.rochester.edu
Stephen Craxton	Laboratory for Laser Energetics, University of Rochester	scra@llle.rochester.edu
Andrei Maximov	Laboratory for Laser Energetics, University of Rochester	amax@lle.rochester.edu
Robert Short	Laboratory for Laser Energetics, University of Rochester	rsho@lle.rochester.edu
Alexis Casner	CEA	alexis.casner@cea.fr
Wallace Manheimer	RSI Company	manheime@ccf.nrl.navy.mil
Juan Fernandez	Los Alamos National Laboratory	juanc@lanl.gov
Kazuto Otani	Institute of Laser Engineering, Osaka University	kotani@ile.osaka-u.ac.jp
Nathan Meezan	Lawrence Livermore National Laboratory	meezan1@llnl.gov
Hitoshi Sakagami	National Institute for Fusion Science	sakagami.hitoshi@nifs.ac.jp
Joseph Oreg	ARTEP, Inc.	oregj@bgu.ac.il
Avraham Barshalom	NRCN	avibs@bgu.ac.il
Gerald Faussurier	CEA	gerald.faussurier@cea.fr
Atsushi Sunahara	Institute of Laser Engineering, Osaka Univ.	suna@ile.osaka-u.ac.jp
Carmen Constantin	UC Davis	constantin1@llnl.gov
Frank Djuth	Geospace Research, Inc.	djuth@ix.netcom.com
Tatsufumi Nakamura	Institute of Laser Engineering, Osaka University	nakamura@ile.osaka-u.ac.jp
Jean-claude Adam	CNRS	adam@cpht.polytechnique.fr
David Eder	Lawrence Livermore National Laboratory	deder@llnl.gov
Vladimir Smalyuk	Laboratory for Laser Energetics, University of Rochester	vsma@lle.rochester.edu
Sean Regan	Laboratory for Laser Energetics, University of Rochester	sreg@lle.rochester.edu
Craig Sangster	Laboratory for Laser Energetics, University of Rochester	csan@lle.rochester.edu
Denis Pesme	CNRS/Ecole Polytechnique	pesme@cpht.polytechnique.fr
Alice Koniges	Lawrence Livermore National Laboratory	koniges@llnl.gov
Brian Spears	Lawrence Livermore National Laboratory	spears9@llnl.gov
Jay Fahlen	UCLA	jfahlen@ucla.edu
Brenton Watkins	Geophysical Institute	bjw4072@mailblocks.com
Kirk Flippo	Los Alamos National Laboratory	kflippo@lanl.gov
Eric Harding	University of Michigan	eharding@umich.edu

Author Index