

*Edited by Heinrich Hora
and George H. Miley*



Laser Interaction

and Related Plasma Phenomena

Volume 6

Laser Interaction and Related Plasma Phenomena

Volume 6

Edited by

Heinrich Hora

*The University of New South Wales
Kensington, New South Wales, Australia*

and

George H. Miley

*University of Illinois
Urbana, Illinois*

PLENUM PRESS • NEW YORK AND LONDON

Library of Congress Cataloging in Publication Data

Main entry under title:

Laser interaction and related plasma phenomena.

Proceedings of the 1st- workshops, held at Rensselaer Polytechnic Institute, 1969-

Includes bibliographies.

1. High temperature plasmas—Congresses. 2. Controlled fusion—Congresses. 3. Lasers—Congresses. I. Schwarz, Helmut J., 1915- ed. II. Hora, Heinrich, ed. III. Rensselaer Polytechnic Insstitute, Troy, N.Y.

QC718.5.HL37 1971

530.44

79-135851

ISBN 0-306-41395-7

Proceedings of the Sixth Workshop on Laser Interactions and Related Plasma Phenomena, held October 25-29, 1982, at the Naval Postgraduate School, Monterey, California

© 1984 Plenum Press, New York
A Division of Plenum Publishing Corporation
233 Spring Street, New York, N.Y. 10013

All rights reserved

No part of this book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, microfilming, recording, or otherwise, without written permission from the Publisher

Printed in the United States of America

PREFACE

This 6th International Workshop in the series starting in 1969 was held at the Naval Postgraduate School in Monterey, California from 25-29 October, 1982 under the continuing directorship of Heinrich Hora. The co-directorship of the late Helmut Schwarz who helped found the series was assumed by George Miley. Fred Schwirzke served as the local organizer. Following a commemoration for Helmut Schwarz, Heinrich Hora commented that the long title of the workshop is originally due to Nicholas Bloembergen, who prophetically envisaged that "related plasma phenomena" such as is involved in particle beam fusion is also of enormous interest to the laser community. The enthusiastic response of the workshop advisors and the 82 participants from 11 countries supports the need for a continuation of this workshop-type meeting where an immediate discussion and documentation of new results and conceptual formulations occurs, a process not possible through the usual journals. The main sponsor of this year's conference was the Fusion Studies Laboratory of the University of Illinois. Thanks are also due to the Naval Postgraduate School, Monterey, and the Department of Theoretical Physics, University of New South Wales. The conference was made feasible by the contributions of the participants, and they and their institutions deserve many thanks. Special recognition is due to the Conference Secretary, Chris Stalker (Urbana), as well as to Marie Wesson (Sydney) and to Patricia Vardaro (Monterey).

This year's Workshop contained sessions on lasers and laser-produced radiation sources, laser interaction with electrons and free electron lasers, interaction diagnostics, interaction dynamics, electron transport, inertial confinement fusion (ICF), ion beam fusion, ICF reactors, and laser acceleration of charged particles.

In view of the wide range of topics covered, it is exceedingly difficult to provide a complete overview here. Indeed, the reader is advised to go through the articles contained in this proceedings in detail since many important new results are presented. At this point, however, we would like to reflect on some points gained from discussions that are related to ICF development. Again, it must be stressed that these reflections are personal views, largely based on

notes compiled by H. Hora during the Workshop. As such they are far from complete and do not necessarily imply a consensus opinion.

Progress in development of large ICF laser facilities has been impressive. In plenary-session discussions, Ken Manes (Livermore) described how the Nova-experiments in 1985 will approach breakeven, and how they form an intermediary step towards reactor scale experiments. The large-scale Nova laser and the 74-cm beam diameter Novette-laser with minimum maintenance disc amplifiers underlined Manes' confidence. The CO₂ laser Antares, described by P. D. Goldstone (Los Alamos), is nearing completion and is also very impressive with 0.7 nsec - 40 kJ (or 0.15 nsec - 15 kJ).

The importance of space-charge effects (electrostatic double layers) between all hot plasmas and the neighboring vacuum or cold target material was emphasized in several discussions. These double layers (Debye-sheath at expansion to the vacuum) were recognized in earlier publications (Mendel & Olsen, 1975; Pearlman and Dahlbacka, 1977) and were cited as the cause for an upshift of 0.5 MeV observed in measurements of emerging fusion alphas (Gazit et al. 1979). Fields of 10^8 V/cm were reported from two-fluid codes at 10^{16} W/cm² Nd glass laser interaction by P. Lalouis et al. (U. New South Wales) who also described many details of electrostatic oscillations. S. Eliezer et al. (Soreq, Israel) reported a very careful measurement (and analysis) of the charging of the target for Nd glass-laser intensities from 10^{12} to 10^{15} W/cm². They found potentials of 10^4 V for electrons and 10^5 V for ions.

Space charge effects can, in principal, prevent the penetration of electrons (apart from a small number restricted by the Debye length) to the target interior. This could be beneficial relative to preheat only in the pulse but harmful later after peak compression is achieved. The reduction of the thermal conductivity with profile steepening is a well known (but not explained) fact and it may well be that the low intensity-long pulse ablation-mode compression also suffers from space-charge suppression of heat transport to the compressed core. Indeed, the general observation that yields from such targets is less than predicted from detailed codes could be due to double-layer effects not yet included in the codes.

Also the theory of high preheat with fast pusher compressions may need revision. Despite the normally expected "fast electrons", using X-ray line diagnostics, B. Yaakobi et al. (LLE Rochester) measured low temperatures in the pellet interior. Roy Johnson et al. (KMS) obtained 10^8 neutrons from pellets with a frozen DT layer on the glass wall while the pellet interior was essentially a void and therefore immune to pre-heating. It may be that fast electrons cannot move into the pellet due to electrostatic forces; in that case, the relatively low compressions observed experimentally may be due to asymmetries. The shorter interaction time does not

permit thermal smoothing and Rayleigh-Taylor instabilities (discussed by R. Morse et al. of the U. Arizona) and/or Helmholtz-Kelvin instabilities (most drastically illustrated by T. Yabe et al. of ILE, Osaka), can destroy the desired compression symmetry. Consequently, direct drive targets may require conditions for ultra uniform illumination at the pellet surface. In discussions by R. Johnson of KMS and S. Skupsky and R. McCrory of LLE, Rochester, variations typical of current illumination are estimated to be $< 2\%$. This analysis used a theory based on Legendre's polynomials to determine the beam characteristics. This confirms some of the global statements of Kidder (1977). Then, taking into account the lateral thermal smoothing during 100-psec irradiation, the deviation from the uniformity is calculated to be only 0.3%. Still, it is not clear that this is adequate.

Along this line, much discussion arose about the generation of fine plasma jets from laser irradiated pellets as described by O. Willi (Rutherford). In this connection, it might be noted that the Osaka group published an early description of jetting. O. Willi et al. showed very detailed pictures of the jets. He also described a periodic ring structure of X-ray emission from irradiated foils where the foil was far removed from the laser focus. It was mentioned in discussions that the mechanism for the jets (hot spots of irradiation, instabilities, magnetic fields, or space charge) needs study so that control methods can be developed.

The problems of nonuniform irradiation were also mentioned by C. E. Max (Livermore) who considered the temporal dependence of the hot spots during one pulse length. She described the nonuniformity of continuous spectra re-emitted from 10^{15} W/cm² irradiated gold targets which appear with a periodicity starting at 30 psec and ending at 80 psec. This suggests that short wave lengths may not always be favorable was received by the audience with surprise and by Co₂ laser protagonists with hope.

The alternative to ultra smooth irradiation is to adopt the concept of hohlraum target (see J. Nuckolls, Phys. Today, Sept. 1982) where the compression is driven indirectly. The laser radiation is transferred at the pellet surface into large amounts of X rays that are uniformly absorbed in a high-Z layer in the structured target, causing a gas-dynamic ablation and compression at that surface. This provides an automatic smoothing process. One experimental result described at the meeting is then of special importance: D. Babonneau et al. (Limeil, France) reported on the 50% conversion of 350-nm Nd laser harmonic radiation incident on gold targets into X rays.

A related approach is the use of the "cannon ball" targets as reported by S. Nakai and C. Yamanaka (ILE Osaka). This "Osaka

effect" was discussed earlier by T. Yabe of this group. The target consists in an outer heavier shell followed by vacuum and then by an inner compact core. Two CO₂ laser beams are focussed half-tangentially to holes in the outer shell and spread grazingly into the vacuum. The conference received a preliminary report on the first 15 shots using these targets: CO₂ laser pulses of 100J produced 10⁷ neutrons with D-D fueled targets. This represents a higher gain than normally expected, suggesting rather efficient cannon-ball operation.

Despite all these strong arguments in favour of using indirect drive techniques, the direct drive concept was supported by several major ICF laboratories (Rochester, Limeil, KMS etc.). An overall evaluation of this approach was presented in S. Bodner's paper (Naval Research Lab., Washington DC) which contains a detailed estimate of efficiency achievements and requirements for each step involved in direct-drive ICF power production. Bodner's comments on the necessary laser uniformity are encouraging based on the hope that the new concept of induced spatial coherence is successful. Still, he underlines that: "From the principles of optics, such a uniformity should be possible, but it will require heroic efforts."

In conclusion, there is a concern that the long-pulse low-intensity ablation-mode compression may create electrostatic double-layer effects that prevent energy transport to the compressed core. On the other hand, there is some evidence that the fast pushers may have low compression due to asymmetries rather than fast-electron preheat. Alternatives are to increase the symmetry of irradiation with fast pushers for direct irradiation, or to smooth the irradiation with indirect illumination (X ray driven hohlraum targets or CO₂-laser driven cannon-ball target). But no one knows how the space-charge effects may modify all this. As an alternative it was noted that a nonlinear-force driven ablation/compression such as proved by the here reported experiments of M. D. J. Burgess, B. Luther-Davies et al. will not be modified by space-charge effects.

For the discussion of ion beam fusion, Cooperstein (NRL) clarified that the observations of Gamble and Phyton are well in agreement with the assumption that the ratio of cross sections are much higher for electrons collisions than for fusion. In his historical remarks, H. Hora indicated, however, that the complex nonlinear dynamics for very intensive beams do predict higher gains than the linear application of the cross section ratio would permit. The doctrine of necessary plasma equilibrium, the need for magnetic confinement, and the theorem that fusion by "accelerated beams of deuterons bombarding a target will not work" may be overcome if success continues in these intense beam experiments and, at the same time, the predictions based on complicated nonlinear interaction dynamics are realized.

We are grateful for the help and encouragement by the Workshop advisors: N. G. Basov (P. N. Lebedev Physical Institute of the Academy of Sciences, Moscow, USSR), J. L. Bobin (Commissariat a l'Energie Atomique, France), J. L. Emmett (Lawrence Livermore National Laboratory, USA), E. Fabre (Ecole Polytechnique, France), A. H. Guenther (Kirtland Air Force Base, USA), R. Hofstadter (Stanford University, USA) M. H. Key (Rutherford Labs, England) R. E. Kidder (Lawrence Livermore National Laboratory, USA). P. Mulser (Technische Universitat, Darmstadt, Germany), M. Richardson (University of Rochester, USA), R. Singer (Los Alamos National Laboratory, USA) and C. Yamanaka (Osaka University, Japan). University of Illinois staff made additional essential contributions to the conference and proceedings. Mark Zediker and David Harris ran the registration desk. David Harris assisted in proofing of papers and preparation of the index while Barbara Murphy and Ruth Mann performed extensive typing for the final preparation of the proceedings. The dedication and enthusiasm of all concerned is gratefully acknowledged. The extensive effort that went into the preparation of articles for these proceedings by the speakers and their colleagues is especially appreciated.

Heinrich Hora
George Miley

CONTENTS

I. LASERS AND SOURCES

Novette, a Short Wavelength Laser-Target Interaction System . . .	1
K. R. Manes, D. R. Speck, G. J. Suski, O. Barr, D. Gritton, S. Hildum, B. Johnson, D. Kuizenga, H. Patton, and C. Thompson	
The Antares Facility for Inertial Fusion Experiments	
- Status and Plans	21
P. D. Goldstone, G. Allen, H. Jansen, A. Saxman, S. Singer, and M. Thuot	
Interhalogen Lasers	33
Steven J. Davis	
Review of Nuclear Pumped Lasers	47
George H. Miley	
Nuclear Pumped Lasers Utilizing Radiant Transfer	73
John D. Cox, Richard T. Schneider, and Y. S. Tang	
Generation of Vacuum Ultraviolet and Extreme Ultraviolet Radiation by Nonlinear Processes with Excimer Lasers	87
C. K. Rhodes	
Resonantly-Pumped Soft X-Ray Lasers Using ICF Drivers	99
Peter L. Hagelstein	
Multistep Pumping Schemes for Short-Wave Lasers	107
George C. Baldwin	
Development of a High Power Glass Laser System and Research of X-Ray Generation	127
Noboru Nakano, Motoyoshi Nagase, Yuichi Tanaka, and Hiroto Kuroda	
Applications of X-Rays From Laser Produced Plasmas	149
H. M. Epstein, R. L. Schwerzel and B. E. Campbell	

II. LASER INTERACTION WITH ELECTRONS AND FREE ELECTRON LASERS

A Glow Discharge Laser Amplifier and its Relation to the Effect of Quantum Modulation of Electron Beams by Lasers 165
 Y. Ben-Aryeh, J. Felsteiner, J. Politch, and A. Rosenberg

A Look at the Free Electron Laser and its Potential 181
 Todd Iversen Smith

High Intensity Free Electron Lasers for Inertial Confinement Fusion 193
 Donald Prosnitz

The Lateral Injection Free Electron Laser: Momentum Balance and Axial Shift of Electrons 201
 H. Hora and G. Viera

III. INTERACTION DIAGNOSTICS

Laser Interaction and Compression Studies at the Rutherford Appleton Laboratory 209
 Oswald Willi, C. I. R. Duncan, R. G. Evans, C. J. Hooker, Z. Q. Lin, M. H. Key, A. Raven, I. N. Ross, P. T. Rumsby, W. T. Toner, M. S. White, A. J. Cole, J. D. Kilkenny, P. F. Cunningham, M. J. Lamb, C. L. S. Lewis, P. McCavana, and S. Sadaat

Laser-Plasma Interaction Experiments and Diagnostics at NRL 235
 B. H. Ripin, J. Grun, M. J. Herbst, S. T. Kacenjar, E. A. McLean, S. P. Obenschain, J. A. Stamper, R.R. Whitlock and F.C. Young

ICF Diagnostics 253
 Lamar W. Coleman

Fusion Product Energy Loss Measurements 263
 G. H. Miley, D. B. Harris, A. H. Bennish, D. R. Welch and C. K. Choi

The Study of Plasma Turbulence by the Method of Combination Scattering 283
 N. G. Basov, M. V. Osipov, A. A. Rupasov, G. V. Sklizkov and A. S. Shikanov

X-Ray Shadowgraphy Studies in Laser Implosion Experiments	299
Danièle Billon, Didier Galmiche, Jacques Launspach, and Daniel Meynial	
New Measurement Techniques Using Tracers Within Laser-Produced Plasmas	317
M. J. Herbst, P. G. Burkhalter, D. Duston, M. Emery J. Gardner, J. Grun, S. P. Obenschain, B. H. Ripin, R. R. Whitlock, J. P. Apruzese, and J. Davis	
Laser Induced Unipolar Arcing	335
Fred Schwirzke	
Investigation of Highly Ionized Plasma Plumes Generated by CO ₂ Laser Irradiation of Solid Targets in Strong Axial Magnetic Fields	353
Edward A. Crawford and Alan L. Hoffman	
Laser Pellet Plasmas for Filling Magnetic Confinement Configurations	369
L. L. Lengyel, H. Brinkschulte, and I. Bozsik	

IV. INTERACTION DYNAMICS

Atomic Physics in Inertial Fusion	379
J. T. Larsen and D. J. Tanner	
Hypothesis for the Quantization of Electrodynamic Parameters in Plasmas Applied to the Equations of Motion	395
Heinrich Hora	
High Harmonic Generation in High Power Lasers	401
Celso Grebogi, Vipin K. Tripathi, and Hsing-Hen Chen	
Review of Recent Experimental and Theoretical Laser- Plasma Research Carried out at Soreq	417
S. Eliezer, B. Arad, A. Borowitz, Y. Gazit, I. Gilath, S. Jackel, A. D. Krumbein, R. Lalluz, H. M. Loebenstein, A. Ludmirsky, Y. Paiss, D. Salzman, N. Spector, A. Sternlieb, H. Szichman and A. Zigler	

Absorption, Double Layers, and Dynamics at Laser-Plasma Interaction and Pellet Fusion Gains with Reheat	437
L. Cicchitelli, R. Dragila, K. I. Golden, H. Hora, D. A. Jones, L. G. Kemeny, G. W. Kentwell, P. Lalousis, M. P. Goldsworthy and G. Tubbenhauer	
The State of Ultra-High Intensity Laser Plasma Interaction Research in Australia	461
M. D. J. Burgess, R. Dragila, B. Luther-Davies, K. A. Nugent, and G. J. Tallents	
Suprathermal Electron Generation Transport and Deposition in CO ₂ Laser Irradiated Targets	479
A. Hauer, R. Goldman, R. Kristal, M.A. Yates, M. Mueller, F. Begay, D. van Hulsteyn, K. Mitchell, J. Kephart, H. Oona, E. Stover, J. Brackbill, and D. Forslund	
Hot Electron Production by Raman Scattering in a Preformed Underdense Plasma	493
R. D. Brooks, R. G. Berger, and Z. A. Pietrzyk	
Scaling of Laser-Plasma Interactions with Laser Wavelength and Plasma Size	507
C. E. Max, E. M. Campbell, W. C. Mead, W. L. Kruer, D. W. Phillion, R. E. Turner, B. F. Lasinski, and K. G. Estabrook	
High Frequency Instabilities in Underdense Plasmas Produced by a 0.35 μ m Laser Beam	527
H. Figueroa, C. Joshi, C. E. Clayton, H. Azechi, N. A. Ebrahim, and K. Estabrook	
Observations of Parametric Instabilities in Long Scalelength Plasmas	545
E. M. Campbell, C. E. Max, M. D. Rosen D. W. Phillion, R. E. Turner, K. Estabrook, B. Lasinski, W. L. Kruer, and W. C. Mead	
Recent Advances in Microwave Simulation of Laser- Plasma Interactions	561
J. S. DeGroot, K. Mizuno, R. A. James, T. A. Hargreaves, D. A. Rasmussen, E. W. Y. Ng, M. A. Kodis, J. H. Rogers, Wee Woo, and P. W. Rambo	

Self-Consistent Electron Density Profiles in Short Pulse, 1.054 μ m Laser-Heated Plasmas	577
P. Ladrach and J. E. Balmer	
Raman and Brillouin Scattering, Classical Reflection, and Relativity	599
Peter Mulser	
Saturation of Stimulated Brillouin Backscatter	605
H. E. Huey, N. C. Luhmann Jr., and C. Pawley	
Space and Time Evolution of SBS Ion Waves and Harmonics . . .	621
C. E. Clayton, C. Joshi, and F. F. Chen	
Filamentation Instability in Laser Produced Plasmas	633
O. Willi, P. T. Rumsby and Zunqi Lin	

V. PELLET FUSION

Critical Elements of High Gain: An Update	665
Stephen Bodner	
Analysis of Stability and Symmetry Implications for ICF . . .	673
J. H. Gardner, S. E. Bodner, J. P. Boris, M. H. Emery, M. J. Fritts, and M. J. Herbst	
Direct Illumination Spherical Target Experiments	693
Roy R. Johnson	
Investigation of Hydrodynamic Stability of High Aspect Ratio Targets in Laser Implosion Experiments	709
J. M. Dufour, D. Galmiche and B. Sitt	
Thermal Transport Measurements in 1.05 μ m Laser Irradiation of Spherical Targets	731
B. Yaakobi, J. Delettrez, R. L. McCrory, R. Marjoribanks, M. C. Richardson, D. Shvarts, J. M. Soures, C. Verdon, D. M. Villeneuve, T. Boehly, R. Hutchison, and S. Letzring	
Uniformity of Energy Deposition for Laser Driven Fusion . . .	751
S. Skupsky, R. L. McCrory, R. S. Craxton, J. Delettrez, R. Epstein, K. Lee, and C. Verdon	

Rayleigh-Taylor Instability and Resulting Failure Modes of
Ablatively Imploded Inertial Fusion Targets 775
L. Montierth and R. Morse

High Density Transition Laser Driven Implosions 797
C. Bayer, M. Bernard, M. Decroisette,
D. Juraszek, and D. Meynial

X-Ray Emission Experiments at 1.06 μ m and 0.35 μ m 817
D. Babonneau, D. Billon, J. L. Bocher,
G. Di Bona, X. Fortin and G. Thiell

Laser Implosion Fusion Experiments at Ile Osaka 839
S. Nakai, T. Yamanaka, Y. Izawa, Y. Kato,
M. Nakatsuka, M. Yamanaka, T. Mochizuki,
K. Yoshida, Y. Kitagawa, and C. Yamanaka

Theoretical and Computational Investigation on
Implosion Process 857
Takashi Yabe, Akio Nishiguchi, Kunioki Mima,
Katsunobu Nishihara and Chiyoe Yamanaka

Recent Studies in Electron Transport and Laser
Interaction at INRS-ENERGIE 869
H. Pépin, T. W. Johnston, J. C. Kieffer, P. Lavigne
F. Martin, J. P. Matte, D. Pascale,
G. Picard, M. Piché, J. Sabbagh,
N. McCarthy, R. Decoste, and G. Mitchel

Instability and Chaos in Some Non-Linear Laser
Interaction Mechanisms 893
J. L. Bobin

Progress Toward Direct Drive Laser Fusion 903
M. C. Richardson, T. R. Boehly, B. A. Brinker
T. C. Bristow, R. S. Craxton, J. A. Delettrez,
G. Enright, A. Entenberg, W. Friedman,
L. M. Goldman, J. Hoose, R. J. Hutchinson,
L. Iwan, S. Kacendar, K. Lee, S. A. Letzring,
L. D. Lund, R. S. Marjoribanks, R. L. McCrory,
J. M. Miller, J. Rizzo, W. D. Seka, S. Skupsky,
J. M. Soures, C. P. Verdon, D. M. Villeneuve
E. A. Williams, and B. Yaakobi

VI. ION BEAM FUSION

Historical Remarks on Beam Fusion 927
Heinrich Hora

CONTENTS

Advances in ICF Using Light Ion Beams 937
 Gerold Yonas and J. Pace VanDevender

Status of Light Ion Inertial Fusion Research at NRL 957
 G. Cooperstein, P. F. Ottinger, Shyke A.
 Goldstein, R. J. Barker, D. G. Colombant,
 R. A. Meger, J. M. Neri, D. Mosher, F. L.
 Sandel, S. J. Stephanakis, and F. C. Young

Inertial Confinement Fusion by Light Ion Beam 981
 S. Miyamoto, T. Ozaki, A. Yoshinouch,
 S. Higaki, K. Imasaki, S. Nakai, and
 C. Yamanaka

Space - Time Focused Light Plasma Beams for ICF Fusion 997
 D. A. Phelps, D. B. Chang, C. B. Wharton,
 W. B. Thompson, S. Jorna, A. Fisher,
 N. Rostoker, and W. W. Salisbury

Ion Beam Interactions with ICF Targets 1013
 Roger O. Bangerter

Ions Stopping in ICF Plasmas 1029
 C. Deutsch, G. Maynard, and H. Minoo

VII REACTORS

ICF Reactor Using a ³He-Aflint Tritium Self-
 Sufficient Target 1049
 G. H. Miley, C. K. Choi, J. F. Stubbins,
 M. Ragheb, and B. Adams

Conceptual Design of ICF Reactor Senri, Part II
 Advances in Design and Pellet Gain Scaling 1061
 Shunji Ido, Ryusuke Tsuji, Kunioki Mima,
 Sadao Nakai and Chiyoe Yamanaka

VIII. HIGH ACCELERATION OF CHARGED PARTICLES

Electron (and Positron) Acceleration with Lasers 1083
 R. H. Pantell

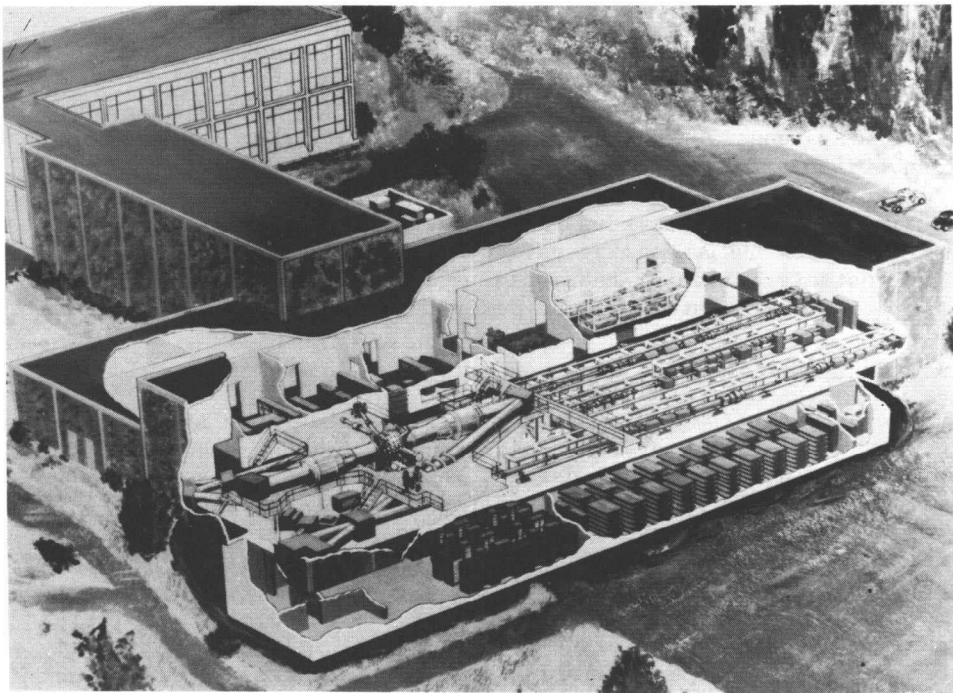
High Energy Particle Acceleration by a Laser Beatwave 1093
 D. J. Sullivan and T. Tajima

GeV Ions From Laser Produced Plasmas	1111
D. A. Jones, E. L. Kane, P. Lalouis, and H. Hora	
Relativistic Electromagnetic Waves in an Electron-Ion Plasma	1129
Abraham C.-L. Chian and Charles F. Kennel	
Attendees	1143
Author Index	1151
Subject Index.	1157

NOVETTE, A SHORT WAVELENGTH LASER-TARGET INTERACTION SYSTEM*

K. R. Manes, D. R. Speck, G. J. Suski, O. Barr,
D. Gritton, S. Hildum, B. Johnson, D. Kuizenga,
H. Patton, and C. Thompson

Lawrence Livermore National Laboratory
P. O. Box 5508, Livermore, CA 94550



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