

**LASER AND
PARTICLE BEAMS**

Laser and Particle Beams

Physics of High Energy Densities

Editor in Chief: HEINRICH HORA

Head, Department of Theoretical Physics
University of New South Wales
Kensington 2033, Australia

Associate Editors:

T P DONALDSON (for UK)
Cambridge University Press
The Edinburgh Building
Shaftesbury Road
Cambridge CB2 2RU
R. DAUTRAY (for Europe)
Scientific Director, CEA Limeil, B.P. 27
94190 Villeneuve St. Georges, France
and G. H. MILEY (for USA)
Director, Fusion Studies Laboratory,
University of Illinois,
103 S. Goodwin Ave., Urbana, IL 61801,
USA

Editorial Board

N. G. Basov (Moscow)
T. J. M. Boyd (Bangor, Wales)
G. Cooperstein (Washington)
S. Eliezer (Yavne, Israel)
J. L. Emmett (Livermore)
A. H. Guenther (Kirtland AFB)
M. H. Key (Rutherford Appleton Laboratory)
J. D. Kilkenny (Imperial College, London)
R. L. McCrory (Rochester)
P. Mulser (Darmstadt)
K. Niu (Nagatsuta)
L. I. Rudakov (Moscow)
D. D. Ryutov (Novosibirsk)
S. Singer (Washington)
J. P. Watteau (CEA Limeil)
C. Yamanaka (Osaka)
K. Yatsui (Nagaoka)
G. Yonas (Washington)

Laser and Particle Beams is an international journal which covers the generation, and the interaction with matter, of high intensity laser and particle beams. It also covers the physics of systems with high energy densities. Specific fields of interest include nuclear fusion, especially inertial confinement, magnetic confinement, diagnostics, material treatment, laboratory astrophysics, plasmas and spectroscopy at extreme conditions, physical properties of hot dense matter and intense particle beams and optical (laser) beams from the microwave to the X-ray region. The exploration of these fields and their new physics, including nonlinear and nonclassical phenomena, should find a forum in this journal.

As well as publishing original articles the journal will also publish occasional review articles, surveys of research at particular laboratories and reviews of recent books.

© Cambridge University Press 1986

Copying: This journal is registered with the Copyright Clearance Center, 21 Congress St., Salem, Mass. 01970. Organizations in the USA who are also registered with C.C.C. may therefore copy material (beyond the limits permitted by sections 107 and 108 of US copyright law) subject to payment to C.C.C. of the percopy fee of \$05.00. This consent does not extend to multiple copying for promotional or commercial purposes. Code 0263-0346/86/0000-\$004\$05.00.

ISI Tear Service, 3501 Market Street, Philadelphia, Pennsylvania 19104, USA, is authorised to supply single copies of separate articles for private use only.

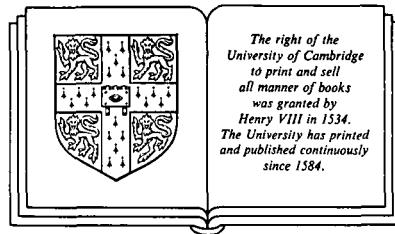
For all other use, permission should be sought from Cambridge or the American Branch of Cambridge University Press.

Subscriptions: *Laser and Particle Beams* (ISSN 0263-0346) is published quarterly. The subscription price (which includes postage) of volume 4, 1986 is £58 net (US \$140 in USA and Canada). Single parts cost £17 net (US \$41 in USA and Canada) plus postage. Four parts form a volume. Orders, which must be accompanied by payment, may be sent to a bookseller, subscription agent or direct to the publishers: Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 2RU. Orders from the USA and Canada should be sent to Cambridge University Press, 32 East 57th Street, New York, NY 10022, USA. Copies of the journal for subscribers in the USA and Canada are sent by air to New York to arrive with minimum delay. Second class postage paid at New York, NY, and at additional mailing offices. POSTMASTER: send address changes in USA and Canada to *Laser and Particle Beams*, Cambridge University Press, 32 East 57th Street, New York, NY 10022.

LASER AND PARTICLE BEAMS

VOLUME 4

1986



CAMBRIDGE UNIVERSITY PRESS
CAMBRIDGE
LONDON NEW YORK NEW ROCHELLE
MELBOURNE SYDNEY

Published by the Press Syndicate of the University of Cambridge
The Pitt Building, Trumpington Street, Cambridge CB2 1RP
32 East 57th Street, New York, NY 10022, USA
10 Stamford Road, Oakleigh, Melbourne 3166, Australia

© Cambridge University Press 1986

Printed in Great Britain by Universities Press (Belfast) Ltd, Belfast BT6 9HF

CONTENTS OF VOLUME 4

TABLE OF CONTENTS LASER AND PARTICLE BEAMS

Vol. 4 1986
(Book reviews in cursive letters)

PART 1 FEBRUARY 1986

| | |
|---|-----|
| R. J. Jensen and Participants in the Los Alamos Advanced Laser Program: Los Alamos krypton fluoride laser program | 3 |
| H. Daido, M. Fujita, K. Terai, F. Miki, K. Nishihara, M. Murakami, K. Mima, S. Nakai, C. Yamanaka and A. Hasegawa: Observation of long life plasma generated in a cavity by CO ₂ lasers | 17 |
| J. Badziak, M. Borzecki, A. Chojnacka, Z. Dźwigalski, K. Janulewicz, R. Jarocki, A. Kalbarczyk, J. Kubicki, Z. Kurzyński, L. Perliński, Z. Sikorski and J. Teter: Short-pulse CO ₂ laser systems for plasma investigation at the IPPLM | 27 |
| T. Yamanaka, T. Mochizuki, H. Azechi, H. Nishimura, M. Yamanaka, N. Miyanaga, H. Niki, E. Fujiwara, H. Shiraga, K. Okada, S. Sakabe, Y. Kato, Y. Kitagawa, M. Nakatsuka, K. Yoshida, Y. Izawa, T. Norimatsu, K. Mima, K. Nishihara, T. Yabe, S. Nakai and C. Yamanaka: Characteristics of plasmas imploded by ω , 2ω , 3ω and 4ω lasers | 43 |
| L. A. Rosocha, P. S. Bowling, M. D. Burrows, M. Kang, J. Hanlon, J. McLeod and G. W. York, Jr.: An overview of aurora: a multi-kilojoule KrF laser system for inertial confinement fusion | 55 |
| M. Tanimoto, A. Yaoita, I. Okuda, Y. Owadano, Y. Matsumoto and T. Kasai: Prospect of efficient high-power-density operation of KrF*-excimer for fusion driver: characteristics in Kr-rich gas mixtures | 71 |
| H. Hora, J.-C. Wang and P. J. Clark: Increased gain of the lateral-injection free-electron laser and the use of clusters for amplification in the X-ray range | 83 |
| J. A. Sullivan and C. W. von Rosenberg, Jr.: High energy krypton fluoride amplifiers for laser-induced fusion | 91 |
| T. Guishen, Q. Peixia, L. Weiping and C. Youming: A master oscillator with three functions for laser fusion systems | 107 |
| S. Denus, A. Dubik, B. Kaczmarczyk, J. Makowski, J. Marczak, J. Owsik, Z. Patron and M. Szczurek: Optimized four-channel Nd:glass laser system for compression experiments | 119 |
| R. B. Wilcox: Photoconductive switch pulse shaping device for the Nova master oscillator | 141 |
| M. C. Jackson, R. D. Long, D. Lee, N. J. Freeman: Development of X-ray streak camera electronics at AWRE | 145 |
| PART 2 MAY 1986 | |
| A. E. Pozwolski: Fusion by hypervelocity impact | 157 |
| Zhou Xuehua, Chen Liyin and Chen Haitao: Characteristics of a CW'HF chemical laser calculated from a simplified two-dimensional model | 167 |

| | |
|--|-----|
| J.-M. Dolique: Bremsstrahlung collision contribution to entropy generation and attendant radial expansion in a self-pinched high-power relativistic electron beam propagating in a neutral gas | 183 |
| E. J. Lerner: Magnetic self-compression in laboratory plasmas, quasars and radio galaxies.—Part I | 193 |
| E. J. Lerner: Magnetic self-compression in laboratory plasmas, quasars and radio galaxies.—Part II | 215 |
| Lin Zunqui, Tan Weihan, GuMin, Mei Guang, Pan Chengming, Yu Wenyan and Deng Ximing: Temporal and spectral features of the $(3/2)$ ω_0 spatial fine structure in laser irradiated planar targets | 223 |
| Tan Weihan, Yu Wenyan, Lin Zunqui, Bi Wiji, Deng Ximing and Ding Liming: Resonance absorption initiated by self focusing filamentation | 231 |
| R. Dinger, K. Rohr and H. Weber: Plasma ion spectra from laser produced plasmas at $\lambda = 1.06 \mu\text{m}$ and $\lambda = 0.53 \mu\text{m}$ | 239 |
| S. Eliezer and A. Loeb: Two dimensional analytical considerations of large magnetic and electric fields in laser produced plasmas | 249 |
| P. Stroud: Streaming modes in final beam transport for heavy ion beam fusion | 261 |
| Bekir Sami Yilbas: Heating of metals at a free surface by laser irradiation—An electron kinetic theory approach | 275 |
| K. A. Long and N. A. Tahir: Plasma induced energy deposition and radiation transport effects in ion beam heated plane metal targets and analytic solutions of the non-linear radiation conduction equation | 287 |

PARTS 3 AND 4 AUGUST/NOVEMBER 1986

| | |
|---|-----|
| R. G. Evans: Magnetic fields generated by the Rayleigh–Taylor instability | 325 |
| A. A. Offenberger, R. Fedosejevs, P. D. Gupta, R. Popil and Y. Y. Tsui: Experimental results for high intensity KrF laser/plasma interaction | 329 |
| G. Velarde, J. M. Aragones, J. A. Gago, L. Gamez, M. C. Gonzalez, J. J. Honrubia, J. L. Hortal, J. M. Martinez-Val, E. Minguez, J. L. Ocaña, R. Otero, J. M. Perlado, J. M. Santolaya, J. F. Serrano and P. M. Velarde: Analysis of directly driven ICF targets | 349 |
| S. Atzeni, A. Caruso and V. A. Pais: Model equation-of-state for any material in conditions relevant to ICF and to stellar interiors | 393 |
| H. Szichman, D. Salzmann and A. D. Krumbein: Radiative transport and preheat calculations of laser irradiated aluminium targets | 403 |
| R. Fabbro, B. Faral, J. Virmont, H. Pepin, F. Cottet and J. P. Romain: Experimental evidence of the generation of multi-hundred megabar pressures in $0.26 \mu\text{m}$ wavelength laser experiments | 413 |
| J. C. Gauthier, P. Monier, P. Audebert, C. Chenais-Popovics and J. P. Geindre: X-ray spectroscopy of high-Z materials | 421 |
| J. Schmiedberger and M. Vrbová: Iodine photodissociation laser with plasma mirror | 427 |

| | |
|---|-----|
| A. Giulietti, D. Giulietti, M. Lucchesi and M. Vaselli: Laser beam self-focusing in an $n_c/100$ plasma with 20 ns and 3 ns pulses | 435 |
| D. Galmiche, J. P. Nicolle and D. Pesme: Electron acceleration by a localised electric field | 439 |
| H. Schönnagel, H. Gunkel and J. Grzanna: A high energy laser with controlled coherence | 453 |
| J. A. Tarvin, Gar. E. Bush, E. F. Gabl, R. J. Schroeder and C. L. Shepard: Laser and plasma conditions at the onset of Raman scattering in an underdense plasma | 461 |
| H. J. Kull: Rayleigh–Taylor instability: Modes and nonlinear evolution | 473 |
| W. Lampart and J. E. Balmer: Time resolved x-ray emission from laser-produced plasmas with timing fiducial | 495 |
| A. Caruso and C. Strangio: Space-time structure of the light reflected in an experiment on solid matter irradiation by laser light | 499 |
| S. Denus, J. Farny, M. Grudzień, W. Mróz, J. Wołowski, A. A. Karnauhov, A. S. Shikanov, G. V. Sklizkov and Yu. A. Zakharenkov: Determination of the imploded mass in laser-imploded shell targets | 507 |
| S. Denus, H. Fieldorowicz, S. Nagraba, Z. Patron, W. Pawłowicz, A. Wilczyński, J. Wołowski, A. V. Kostierin, Yu. A. Zakharenkov, A. S. Shikanov, G. V. Sklizkov, A. A. Rupasov and M. V. Osipov: Experimental study of laser-driven compression of spherical microshells | 515 |
| K. Eidmann, T. Kishimoto, P. Herrmann, J. Mizui, R. Pakula, R. Sigel and S. Witkowski: Absolute soft x-ray measurements with a transmission grating spectrometer | 521 |
| E. Buresi, J. Coutant, R. Dautray, M. Decroisette, B. Duborgel, P. Guillaneux, J. Launspach, P. Nelson, C. Patou, J. M. Reisse and J. P. Watteau: Laser program development at CEL-V: overview of recent experimental results | 531 |
| O. Larroche, M. Casanova, D. Pesme and M. N. Bussac: Soliton emission in the forced non-linear Schrödinger equation | 545 |
| A. Ng, D. Parfenik, L. Da Silva and P. Celliers: Laser-driven shock wave experiments at the University of British Columbia | 555 |
| D. Giovanielli: Excimer laser development for fusion | 569 |
| J. Corbett, C. L. S. Lewis, E. Robertson, S. Saadat, P. F. Cunningham, A. Cole, E. Trucu, M. H. Key and S. J. Rose: Recent experiments at the Rutherford Appleton Laboratory to study the laser driven compression of CH targets and the effects of increasing aspect ratio | 573 |
| Regular Paper | |
| A. Loeb and S. Eliezer: A gamma ray laser based on induced annihilation of electron–positron pairs | 577 |
| Alphabetic Author Index | 595 |

Information for Contributors

1. Manuscripts must be written in English. All manuscripts will be referred to acknowledged experts in the subject. Only those receiving favourable recommendations from the referees will be accepted for publication. Manuscripts may be sent to any Board member, any Associate Editor or the Editor.
2. The typescript should be double spaced, on one side of good grade paper, allowing a reasonable left-hand margin. An original and two copies should be submitted with the author's full postal address, position and affiliations.
3. The title and section headings should highlight the significant points. A short abstract should precede the main text.
4. One copy of photographs, prints or transparencies of good quality and unmarked should be submitted. Where lines or lettering are to appear on the photograph, an additional print should be supplied appropriately marked. Each should have, lightly written on the back, the author's name, the figure number and an indication of which is the top of the picture.
5. One copy of each line diagram should be submitted at approximately twice final size and unlettered. Diagrams must be drawn in Indian ink on plain white or transparent paper. A second copy should be supplied with lettering included. The author's name and the figure number should be written on this copy.
6. Tables should be typewritten on separate sheets. Avoid, where possible, very wide tables.
7. References and footnotes should be cited according to the Harvard (Author/date system), also known as the "British form". In the text, author and year are cited in brackets e.g. "... was found by McCarthy (1980; 1980a) ..." or "(Emmett *et al.* 1972)". Full references are listed in alphabetic order at the end of the paper. References are not numbered. An example of a reference list is:

DEUTSCH, C. & KLARSFELD, S. 1973 *Phys. Rev. A* **7**, 2081.
NICHOLSON, D. R. 1983 *Plasma Theory*, (John Wiley, New York).
OOMURA, H. *et al.* 1982 *Res. Rep. ILE*, ILE-8207p.
OOMURA, H. *et al.* 1982a *Trans. ANS*, **43**, 617.

Note that the year of publication appears after the author's name. If possible, all authors names should be listed in preference to "*et al.*" If one author or team is referred to more than once in any year, the letters a, b, etc should be added after the year to distinguish the individual references.
8. Correction to proofs should be restricted to printers' errors only. Authors are entitled to 25 offprints of their article free of charge. Additional offprints may be purchased if they are ordered on the form sent with the proofs.

continued from back cover

O. Larroche, M. Casanova, D. Pesme and M. N. Bussac: Soliton emission in the forced non-linear Schrödinger equation 545

A. Ng, D. Parfeniu, L. Da Silva and P. Celliers: Laser-driven shock wave experiments at the University of British Columbia 555

D. Giovanielli: Excimer laser development for fusion 569

J. Corbett, C. L. S. Lewis, E. Robertson, S. Saadat, P. F. Cunningham, A. Cole, E. Trucu, M. H. Key and S. J. Rose: Recent experiments at the Rutherford Appleton Laboratory to study the laser driven compression of CH targets and the effects of increasing aspect ratio 573

Regular Paper

A. Loeb and S. Eliezer: A gamma ray laser based on induced annihilation of electron-positron pairs 577

Conference Report 589

Alphabetic Author Index 595

Contents of Volume 4

LASER AND PARTICLE BEAMS

Volume 4 Parts 3 & 4 August/November 1986

A. Caruso: Guest Editor—Selected papers from ECLIM 85

CONTENTS

H. Hora: Foreword 323

Conference Papers

R. G. Evans: Magnetic fields generated by the Rayleigh–Taylor instability 325

A. A. Offenberger, R. Fedosejevs, P. D. Gupta, R. Popil and Y. Y. Tsui: Experimental results for high intensity KrF laser/plasma interaction 329

G. Velarde, J. M. Aragones, J. A. Gago, L. Gamez, M. C. Gonzalez, J. J. Honrubia, J. L. Hortal, J. M. Martinez-Val, E. Minguez, J. L. Ocaña, R. Otero, J. M. Perlado, J. M. Santolaya, J. F. Serrano and P. M. Velarde: Analysis of directly driven ICF targets 349

S. Atzeni, A. Caruso and V. A. Pais: Model equation-of-state for any material in conditions relevant to ICF and to stellar interiors 393

H. Szychman, D. Salzmann and A. D. Krumbein: Radiative transport and preheat calculations of laser irradiated aluminium targets 403

R. Fabbro, B. Faral, J. Virmont, H. Pepin, F. Cottet and J. P. Romain: Experimental evidence of the generation of multi-hundred megabar pressures in 0.26 μm wavelength laser experiments 413

J. C. Gauthier, P. Monier, P. Audebert, C. Chenais-Popovics and J. P. Geindre: X-ray spectroscopy of high-Z materials 421

J. Schmiedberger and M. Vrbová: Iodine photodissociation laser with plasma mirror 427

A. Giulietti, D. Giulietti, M. Lucchesi and M. Vaselli: Laser beam self-focusing in an $n_e/100$ plasma with 20 ns and 3 ns pulses 435

D. Galmiche, J. P. Nicolle and D. Pesme: Electron acceleration by a localised electric field 439

H. Schönnagel, H. Gunkel and J. Grzanna: A high energy laser with controlled coherence 453

J. A. Tarvin, Gar. E. Bush, E. F. Gabl, R. J. Schroeder and C. L. Shepard: Laser and plasma conditions at the onset of Raman scattering in an underdense plasma 461

H. J. Kull: Rayleigh–Taylor instability: Modes and nonlinear evolution 473

W. Lampart and J. E. Balmer: Time resolved x-ray emission from laser-produced plasmas with timing fiducial 495

A. Caruso and C. Strangio: Space-time structure of the light reflected in an experiment on solid matter irradiation by laser light 499

S. Denus, J. Farny, M. Grudzień, W. Mróz, J. Wołowski, A. A. Karnauhov, A. S. Shikanov, G. V. Sklizkov and Yu. A. Zakharenkov: Determination of the imploded mass in laser-imploded shell targets 507

S. Denus, H. Fieldorowicz, S. Nagraba, Z. Patron, W. Pawłowicz, A. Wilczyński, J. Wołowski, A. V. Kostierin, Yu. A. Zakharenkov, A. S. Shikanov, G. V. Sklizkov, A. A. Rupasov and M. V. Osipov: Experimental study of laser-driven compression of spherical microshells 515

K. Eidmann, T. Kishimoto, P. Herrmann, J. Mizui, R. Pakula, R. Sigel and S. Witkowski: Absolute soft x-ray measurements with a transmission grating spectrometer 521

E. Buresi, J. Coutant, R. Dautray, M. Decroisette, B. Duborgel, P. Guillaneux, J. Launspach, P. Nelson, C. Patou, J. M. Reisse and J. P. Watteau: Laser program development at CEL-V: overview of recent experimental results 531

continued on inside back cover

© Cambridge University Press 1986

Cambridge University Press, The Pitt Building, Trumpington Street, Cambridge CB2 1RP
32 East 57th Street, New York, NY 10022, USA

10 Stamford Road, Oakleigh, Melbourne 3166, Australia

Printed in Northern Ireland by The Universities Press (Belfast) Ltd, Belfast BT6 9HF