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Short Pulse Laser Interactions with Matter **Introduction to Laser-Plasma Interactions** *Investigation of Staged Laser-Plasma Acceleration* **Numerical Simulation of Interaction of Short Pulse Lasers with Plasma Spatiotemporal Pulse Shaping for Laser-plasma-based Applications Commercial and Biomedical Applications of Ultrashort Pulse Lasers Short Pulse Laser and Plasma Surface Interactions (Classic Reprint)** *Laser-Plasma Interaction with Ultra-Short Laser Pulses High-order Harmonic Generation in Laser Plasma Plumes* **High-Power Laser-Plasma Interaction** *Interaction of Electromagnetic Waves and Electron Beams with Plasmas* **Laser Ablation in Liquids Laser-Plasma Interactions 4 Laser-induced Plasmas Resonance Enhancement in Laser-Produced Plasmas** *Compact XUV and X-Ray Sources from Laser-plasma Interactions* **Ion acceleration and extreme light field generation based on ultra-short and ultra–intense lasers The Physics Of Laser Plasma Interactions Frontiers in High Energy Density Physics Applications of Laser-Plasma Interactions Laser-induced Breakdown Spectrometry Plasma Harmonics** *Plasma Production by Laser Ablation, PPLA 2003* Time-resolved Diffraction Generation and Application of Ultrahigh Laser Fields **Short Pulse Laser Interactions With Matter: An Introduction Coherence and Ultrashort Pulse Laser Emission Laser-Plasma Interactions Applications of Laser Plasma Radiation High Energy and Short Pulse Lasers** *X-Rays From Laser Plasmas* **Laser Pulse Phenomena and Applications Laser-Plasma Interactions and Applications** *Optimization of Ion Acceleration from High-intensity Laser-plasma Interactions* Laser Interaction and Related Plasma Phenomena *Topics in High-peak Intensity, Ultrashort Pulse Laser-plasma Interactions* **Atoms, Solids, and Plasmas in Super-Intense Laser Fields Applications of Laser-Plasma Interactions Experimental Investigation of plasma production by irradiating solid hydrogen foils with an intense pulse laser Laser Induced Breakdown Spectroscopy**

Laser-Plasma Interactions and Applications covers the fundamental and applied aspects of high power laser-plasma physics. With an internationally renowned team of authors, the book broadens the knowledge of young researchers working in high power laser-plasma science by providing them with a thorough pedagogical grounding in the interaction of laser radiation with matter, laser-plasma accelerators, and inertial confinement fusion. The text is organised such that the theoretical foundations of the subject are discussed first, in Part I. In Part II, topics in the area of high energy density physics are covered. Parts III and IV deal with the applications to inertial confinement fusion and as a driver of particle and radiation sources, respectively. Finally, Part V describes the principle diagnostic, targetry, and computational approaches used in the field. This book is designed to give students a thorough foundation in the fundamental physics of laser-plasma interactions. It will also provide readers with knowledge of the latest research trends and elucidate future exciting challenges in laser-plasma science. Laser Induced Breakdown Spectroscopy (LIBS) is an emerging technique for determining elemental composition. With the ability to analyse solids, liquids and gases with little or no sample preparation, it is more versatile than conventional methods and is ideal for on-site analysis. This is a comprehensive reference explaining the fundamentals of the LIBS phenomenon, its history and its fascinating applications across eighteen chapters written by recognized leaders in the field. Over 300 illustrations aid understanding. This book will be of significant interest to researchers in chemical and materials analysis within academia and industry. A comprehensive guide to a new technology for enabling high-performance spectroscopy and laser sources Resonance Enhancement in Laser-Produced Plasmas offers a guide to the most recent findings in the newly emerged field of resonance-enhanced high-order harmonic generation using the laser pulses propagating through the narrow and extended laser-produced plasma plumes. The author—a noted expert in the field—presents an introduction and the theory that underpin the roles of resonances in harmonic generation. The book also contains a review of the most advanced methods of plasma harmonics generation at the conditions of coincidence of some harmonics, autoionizing states, and some ionic transitions possessing strong oscillator strengths. Comprehensive in scope, this text clearly demonstrates the importance of resonance-enhanced nonlinear optical effects leading to formation of efficient sources of coherent extreme ultraviolet radiation that can be practically applied. This important resource: Puts the focuses on novel applications of laser-plasma physics, such as the development of ultrashort-wavelength coherent light sources Details both the theoretical and experimental aspects of higher-order harmonic generation in laser-produced plasmas Contains information on early studies of resonance enhancement of harmonics in metal-ablated plasmas Analyzes the drawbacks of different theories of resonant high order harmonic generation Includes a discussion of the quasi-phase-matching and properties of semiconductor plasmas Written for researchers and students in the fields of physics, materials science, and electrical engineering who are interested in laser physics and optics, Resonance Enhancement in Laser-Produced Plasmas offers an introduction to the topic and covers recent experimental studies of various resonance processes in plasmas leading to enhancement of single harmonic. Proceedings of the 30th Course of the International School of Quantum Electronics on Atoms, Solids and Plasmas in Super-Intense Laser Fields, held 8-14 July, in Erice, Sicily The acceleration of the technical capabilities of X-ray, electron and neutron diffraction techniques in recent years has been driven by developments in synchrotron and neutron sources, detectors and computers. These allow the rapid and repeated acquisition of diffraction data as a chemical and biological structural process proceeds, following its initiation. This opens up completely new studies from timescales ranging from the sub-picosecond, at the fastest, through all the time domains up to kiloseconds, for the slower molecular processes. This book gives the readers an introduction to experimental and theoretical knowledge acquired by large-scale laser laboratories that are dealing with extra-high peak power and ultrashort laser pulses for research of terawatt (TW), petawatt (PW), or near-future exawatt (EW) laser interactions, for soft X-ray sources, for acceleration of particles, or for generation of hot dense thermal plasma for the laser fusion. The other part of this book is dealing with the small-scale laser laboratories that are using for its research on commercial sources of laser radiation, nanosecond (ns), picosecond (ps), or femtosecond (fs) laser pulses, either for basic research or for more advanced applications. This book is divided into six main sections dealing with short and ultrashort laser pulses, laser-produced soft X-ray sources, large-scale high-power laser systems, free-electron lasers, fiber-based sources of short optical pulse, and applications of short pulse lasers. In each chapter readers can find fascinating topics related to the high energy and/or short pulse laser technique. Individual chapters should serve the broad spectrum of readers of different expertise, layman, undergraduate and postgraduate students, scientists, and engineers, who may in this book find easily explained fundamentals as well as advanced principles of particular subjects related to these phenomena. This book represents the first comprehensive treatment of high-order harmonic generation in laser-produced plumes, covering the principles, past and present experimental status and important applications. It shows how this method of frequency conversion of laser radiation towards the extreme ultraviolet range matured over the course of multiple studies and demonstrated new approaches in the generation of strong coherent short-wavelength radiation for various applications. Significant discoveries and pioneering contributions of researchers in this field carried out in various laser scientific centers worldwide are included in this first attempt to describe the important findings in this area of nonlinear spectroscopy. High-Order Harmonic Generation in Laser Plasma Plumes is a self-contained and unified review of the most recent achievements in the field, such as the application of clusters (fullerenes, nanoparticles, nanotubes) for efficient harmonic generation of ultrashort laser pulses in cluster-containing plumes and resonance-induced enhancement of harmonic yield. It can be used as an advanced monograph for researchers and graduate students working in the field of nonlinear spectroscopy. It is also suitable for researchers in laser physics and nonlinear optics who wish to have an overview of the advanced achievements in laser ablation-induced high-order harmonic generation spectroscopy. The carefully presented details of this book will be of value to research devoted to the understanding and control frequency conversion of laser pulses in plasma plumes. The studies described in this book pave the way for the development of a new method of materials studies using the laser ablation-induced high-order harmonic generation spectroscopy, which can exploit the spectral and structural properties of various solid-state materials through their ablation and further propagation of short laser pulse through laser-produced plasma and generation of high-order harmonics. This book focuses on the fundamental concepts and physical and chemical aspects of pulsed laser ablation of solid targets in liquid environments and its applications in the preparation of nanomaterials and fabrication of nanostructures. The areas of focus include basic thermodynamic and kinetic processes of laser ablation in liquids, and its applications in metal and metal oxides nanocrystals synthesis and semiconductor nanostructures fabrication. The book comprises theoretical and experimental analysis of laser ablation in liquids, research methods, and preparation techniques. Papers from the April 1995 conference (formerly called a "workshop") are contained in two volumes. The first volume (623-9) comprises contributions arranged in sections on ICF programs and energy drivers; critical elements for ignition--target experiment, physics, and design; laser-matter interaction physics; and high intensities, short pulse interactions. The second volume (624-7) begins with papers on optical technologies and various kinds of lasers--free electron, LD and LD pumped, gas, nuclear pumped, and short pulse. Following these are sections on particle beams--light and heavy ion beam fusions; and applications of laser and plasma. Edward Teller Award lectures complete the proceedings. Not indexed by subject (contains only an author "index"). Annotation copyrighted by Book News, Inc., Portland, OR Pulsed lasers are available in the gas, liquid, and the solid state. These lasers are also enormously versatile in their output characteristics yielding emission from very large energy pulses to very high peak-power pulses. Pulsed lasers are equally versatile in their spectral characteristics. This volume includes an impressive array of current research on pulsed laser phenomena and applications. Laser Pulse Phenomena and Applications covers a wide range of topics from laser powered orbital launchers, and laser rocket engines, to laser-matter interactions, detector and sensor laser technology, laser ablation, and biological applications. Recent advances in the development of lasers with more energy, power, and brightness have opened up new possibilities for exciting applications. Applications of Laser-Plasma Interactions reviews the current status of high power laser applications. The book first explores the science and technology behind the ignition and burn of imploded fusion fue Recent advances in the development of lasers with more energy, power, and brightness have opened up new possibilities for exciting applications. Applications of Laser-Plasma Interactions reviews the current status of high power laser applications. The book first explores the science and technology behind the ignition and burn of imploded fusion fue In this thesis the generation of high order harmonics of ultrashort and high intensity laser pulses from solid density plasmas, so called surface high harmonic generation (SHHG), is studied. With SHHG, a compact source of coherent XUV and X-Ray radiation becomes possible. The results are obtained numerically using 1D and 2D Particle-In-Cell (PIC) computer simulations, which are supported by analytical models. This work focusses on two main issues of SHHG to date, pulse isolation and generation efficiency. It is shown that a single attosecond pulse (AP) can be obtained from a few-cycle incident laser pulse by choosing a suitable carrier-envelope phase (CEP), depending on the density and shape of density gradient of the target. An analytical model providing an interpretation of the results obtained from PIC simulations is presented. Spatial isolation of APs can be achieved using the attosecond lighthouse effect, but surface denting is detrimental to the separation of APs. PIC simulations are used to explain an experimental result, where a separation of pulses was not possible due to surface denting. Furthermore it is shown that the angular spectral chirp corresponds to the depth of the surface denting. The efficiency of SHHG can be enhanced greatly by reflecting the beam coming from a first target off a second target. Of major importance for the efficiency is the relative phase between harmonics on the surface of the second target. The relative phase changes even when propagating in free space due to the Gouy phase. To maximize the efficiency gain, a parametric study using PIC simulations has been performed to find the optimal distance between two targets. Soft X-rays have great potential for use in a wide variety of applications, including the semiconductor industry and the life sciences. X-Rays from Laser Plasmas: Generation and Applications focuses exclusively and in detail on the science and technology of soft X-rays produced with non-synchrotron sources. Using a minimum of mathematical formulae, it discusses how such X-rays can be efficiently and economically generated from plasmas produced by lasers, and how they interact with matter. Authored by Dr Edmond Turcu, one of the pioneers in this field, X-Rays from Laser Plasmas: Generation and Applications will be of great interest to a wide variety of readers, including all those working in X-ray lithography, microscopy, and radiobiology. Covers parametric instabilities, laser charged particle acceleration, surface plasmonics and free electron lasers in depth. Excerpt from Short Pulse Laser and Plasma Surface Interactions High power laser beams interact with targets by a variety of thermal, impulse, and electrical effects. The laser heated plasma causes surface ablation by thermal evaporation, ion sputtering, and unipolar arcing. While the first two are purely thermal and mechanical effects, the last one, unipolar arcing, is an electrical plasma-surface interaction process which leads to crater formation. About the Publisher Forgotten Books publishes hundreds of thousands of rare and classic books. Find more at www.forgottenbooks.com This book is a reproduction of an important historical work. Forgotten Books uses state-of-the-art technology to digitally reconstruct the work, preserving the original format whilst repairing imperfections present in the aged copy. In rare cases, an imperfection in the original, such as a blemish or missing page, may be replicated in our edition. We do, however, repair the vast majority of imperfections successfully; any imperfections that remain are intentionally left to preserve the state of such historical works. When the output from a pulsed laser is forced onto a small spot of a sample, optically induced plasma, called laser-induced plasma (LIP) is formed at the surface. The plasma is formed when the laser power density exceeds the breakdown threshold value of the surface. The plasma can be used in sampling but is proposed as a source for atomic emission spectrometry (AES). In this case the technique is referred to as laser induced breakdown (emission) spectrometry (LIBS). The spectrally and temporally resolved detection and subsequent determination of the specific atomic emission reveals analytical information about the elemental composition of the sample, including solids, liquids and gases. This book is devoted to the analytical technique of laser-induced breakdown spectrometry. An introduction covering some basic principles of atomic emission spectrometry, analytical performance characteristics, and a comparison to more conventional techniques provides background information for the reader. The book is then conveniently divided into three parts: the first part described the instrumentation required and options available, the second part on fundamental studies of the laser plasma, and the third part on applications. Finally the future development of LIBS is presented. In 1985, the invention of the Chirped Pulse Amplification (CPA) technique made it possible to amplify ultra-short laser pulses to high intensities. Nowadays, laser pulses containing only few optical cycles can be amplified to several tens of gigawatt on a daily basis, using compact table top systems, and lasers that even produce pulses of petawatt power are available at international laboratories. This book comprises the specification and description of two experiments which were carried out to research the interaction of high intensity, ultra-short laser pulses with matter. In the first experiment, the ionization front and the plasma channel generated by laser pulses of sub-10-fs duration and gigawatt power were studied using optical shadowgraphy and interferometry. During this experiment the propagation of the front and the evolution of the channel were resolved optically with sub-10-fs time resolution for the first time. The second experiment, which was carried out at the VULCAN Petawatt laser at the Rutherford Appleton Laboratory (UK), included the research of the propagation and filamentation of a laser-produced electron beam through an over-dense plasma. The structure of the beam was observed by imaging the optical transition radiation produced by the MeV electrons. Laser-Plasma Interactions 4 is the fourth book in a series devoted to the study of laser-plasma interactions. Subjects covered include laser light propagation, instabilities, compression and hydrodynamics, spectroscopy, diagnostics, computer code, dense plasmas, high-power lasers, X-UV sources and lasers, beat waves, and transport processes. High-energy (100s MeV), high spectral quality ion beams are important for many applications like radiography of plasmas, isochoric heating of materials, and tumor therapy. Advances in the development of intense short pulse lasers, recognized with the 2018 Nobel Prize in physics, have been seen as a very promising route to drive compact ion beam sources. However, despite signficant progress over the past two decades, the control of the ion beam properties remains an outstanding challenge. In this Thesis, we discuss two approaches for controlling and optimizing these laser-driven ion beams, using particle-in-cell simulations and theoretical analysis. First, we show that in laser radiation pressure acceleration, the spectral quality of the ion beam is determined by electron heating, which is dictated by the growth of a surface instability. We show that its growth rate imposes an upper limit on the laser pulse duration, and can limit the maximum peak ion beam energy. Next, we explore the development of a hybrid accelerator that combines the advantages of laser-driven beams (compact, high-charge, 10s MeV) with high-gradient RF acceleration in a meter-scale linac, eliminating the large and expensive radio frequency quadrupoles for bunching. Our one-to-one simulations show that the space-charge field plays a critical role in the acceleration effectiveness, and that by tuning the distance at which the laser-driven beam enters the RF, the space-charge field can be controlled such that it actually increases the beam capture. These are important in guiding future experimental developments, for example for the ultrashort laser pulses at state-of-the-art laser facilities and high-gradient linacs, for which we showcase the possibility of a compact (4.5 m) hybrid accelerator that produces a high-quality, high-charge 250 MeV proton beam. Generation & Application of Ultrahigh Laser Fields Recent scientific and technical advances have made it possible to create matter in the laboratory under conditions relevant to astrophysical systems such as supernovae and black holes. These advances will also benefit inertial confinement fusion research and the nation's nuclear weapon's program. The report describes the major research facilities on which such high energy density conditions can be achieved and lists a number of key scientific questions about high energy density physics that can be addressed by this research. Several recommendations are presented that would facilitate the development of a comprehensive strategy for realizing these research opportunities. This textbook provides a comprehensive introduction to the physics of laser-plasma interactions (LPI), based on a graduate course taught by the author. The emphasis is on high-energy-density physics (HEDP) and inertial confinement fusion (ICF), with a comprehensive description of the propagation, absorption, nonlinear effects and parametric instabilities of high energy lasers in plasmas. The recent demonstration of a burning plasma on the verge of nuclear fusion ignition at the National Ignition Facility in Livermore, California, has marked the beginning of a new era of ICF and fusion research. These new developments make LPI more relevant than ever, and the resulting influx of new scientists necessitates new pedagogical material on the subject. In contrast to the classical textbooks on LPI, this book provides a complete description of all wave-coupling instabilities in unmagnetized plasmas in the kinetic as well as fluid pictures, and includes a comprehensive description of the optical smoothing techniques used on high-power lasers and their impact on laser-plasma instabilities. It summarizes all the key developments from the 1970s to the present day in view of the current state of LPI and ICF research; it provides a derivation of the key LPI metrics and formulas from first principles, and connects the theory to experimental observables. With exercises and plenty of illustrations, this book is ideal as a textbook for a course on laser-plasma interactions or as a supplementary text for graduate introductory plasma physics course. Students and researchers will also find it to be an invaluable reference and self-study resource. This book represents the first comprehensive treatment of the subject, covering the theoretical principles, present experimental status and important applications of short-pulse laser-matter interactions.Femtosecond lasers have undergone dramatic technological advances over the last fifteen years, generating a whole host of new research activities under the theme of “ultrafast science”. The focused light from these devices is so intense that ordinary matter is torn apart within a few laser cycles. This book takes a close-up look at the exotic physical phenomena which arise as a result of this new form of “light-matter” interaction, covering a diverse set of topics including multiphoton ionization, rapid heatwaves, fast particle generation and relativistic self-channeling. These processes are central to a number of exciting new applications in other fields, such as microholography, optical particle accelerators and photonuclear physics.Repository for numerical models described in Chapter 6 can be found at www.fz-juelich.de/zam/cams/plasma/SPLIM/./a A Solid Compendium of Advanced Diagnostic and Simulation Tools Exploring the most exciting and topical areas in this field, Laser-Plasma Interactions focuses on the interaction of intense laser radiation with plasma. After discussing the basic theory of the interaction of intense electromagnetic radiation fields with matter, the book covers three applications of intense fields in plasma: inertial fusion, wakefield accelerators, and advanced radiation sources. Collecting contributions from a host of international experts, the book provides a thorough grounding in the fundamental concepts of the interaction of electromagnetic radiation with matter, before moving on to selected advanced topics from the field. It describes state-of-the-art diagnostic tools and experimental techniques used to study laser-plasma interactions as well as simulation tools for modeling these interactions. With a focus on current research trends, this book guides readers to the brink of the most stimulating challenges in the field. It also gives readers an appreciation of the underlying phenomena linking several applications. This book is dedicated to the relativistic (laser intensity above 1018 W/cm2) laser-plasma interactions, which mainly concerns two important aspects: ion acceleration and extreme-light-field (ELF). Based on the ultra-intense and ultra–short CP lasers, this book proposes a new method that significantly improves the efficiency of heavy-ion acceleration, and deals with the critical thickness issues of light pressure acceleration. More importantly, a series of plasma approaches for producing ELFs, such as the relativistic single-cycle laser pulse, the intense broad-spectrum chirped laser pulse and the ultra-intense isolated attosecond (10-18s) pulse are introduced. This book illustrates that plasma not only affords a tremendous accelerating gradient for ion acceleration but also serves as a novel medium for ELF generation, and hence has the potential of plasma-based optics, which have a great advantage on the light intensity due to the absence of device damage threshold. Plasma harmonics is a new field of laser spectroscopy. The use of the solid elements of the periodic table, together with thousands of complex solid-state samples, largely extends the range of materials employed in plasma harmonics in contrast to the few light rare gases that are typically used. Thus the exploration of practically any available solid-state material through nonlinear spectroscopy comprising laser ablation and harmonic generation can be considered a new tool for materials science. Plasma harmonic spectroscopy exploits the spectral and structural properties of various ablated solid-state materials by propagating short laser pulses through laser-produced plasma and generating high-order harmonics of ultrashort laser pulses. The book describes the special features of plasma harmonics in laser-produced ablation plumes and discusses a wide range of nonlinear medium characteristics that can be produced by varying the conditions of laser plume production on the surface of a solid. This book compiles and details cutting-edge research in science and medicine from the interdisciplinary team of the Michigan Nanotechnology Institute for Medicine and Biological Sciences, who are currently revolutionizing drug delivery techniques through the development of engineered nanodevices. Edited by Istvan J Majoros and James Baker, Jr., two prominent nanotechnology researchers, this book is designed for workers involved in nanotechnology, macromolecular science, cancer therapy, or drug delivery research. In this volume, recent contributions on coherence provide a useful perspective on the diversity of various coherent sources of emission and coherent related phenomena of current interest. These papers provide a preamble for a larger collection of contributions on ultrashort pulse laser generation and ultrashort pulse laser phenomena. Papers on ultrashort pulse phenomena include works on few cycle pulses, high-power generation, propagation in various media, to various applications of current interest. Undoubtedly, Coherence and Ultrashort Pulse Emission offers a rich and practical perspective on this rapidly evolving field. With the advent of laser and maser, the wave-plasma interaction emerged as a major rich field of research. To explore the possibility of laser driven fusion, laser-plasma interaction became a subject of worldwide research, revealing many novel nonlinear phenomena including generation and saturation of plasma instabilities, electron acceleration, and ion Coulomb explosion. The work presented in this thesis is related to intense laser-plasma and electron beam-plasma interaction. The development of intense short pulse laser and high current, high-energy electron beams has allowed exploration of new regimes of laser and beam plasma interaction. Enormous progress has been made in inertial confinement fusion, plasma heating, X-ray lasers, free electron laser and charged particle accelerators. In these applications parametric instabilities, self-focusing, self phase modulation and other non-linear phenomena are important. The present thesis deals with these phenomena. This work is relevant to laser-driven fusion, charged particle acceleration, and laboratory plasma heating. This volume concerns the latest results on pulsed plasma production by energetic laser pulses irradiating solid targets. The produced plasma emits neutrals, clusters, ions, electrons and photons. Plasma properties depend on the laser pulse duration, energy, wavelength, focusing, target nature and irradiation conditions. Plasma expands in vacuum with supersonic velocity and may accelerate heavy ions, with charge states higher than 50+, at energies higher than 10 MeV. This book presents and discusses possible applications, such as ion injection in ECR ion sources, ion implantation, ion post-acceleration and thin film deposition by the PLD technique. The proceedings have been selected for coverage in: . OCo Index to Scientific & Technical Proceedings- (ISTP- / ISI Proceedings). OCo Index to Scientific & Technical Proceedings (ISTP CDROM version / ISI Proceedings). OCo CC Proceedings OCo Engineering & Physical Sciences. Contents: Experiments on the Laser Injection to ECRIS (G Arzumanyan et al.); Pulsed Laser Deposition of Diamond-Like Carbon Films in Different Ambient Atmospheres (M Bonelli et al.); Pulsed Laser Deposition of Crystalline Silicon Carbide Films (R Reitano et al.); Microscopic Description of Energy Production (A Bonasera); Laser-Produced Ions for Various Applications (L Liska et al.); Diagnostics for Laser Ion Sources (J Krisa et al.); Temperature Measurements by MaxwellOCoBoltzmann Distribution of a Plasma-Laser and Characterization of the Ion Bean (V Nassisi et al.); Flexible Laser Ion Sources for Surface Modification (F P Boody et al.); Aluminium Laser Ablation for Plasma Production (A Piccioto et al.); The Role of Secondary Electron Emission on the ECR Plasma (L Schachter et al.); Multiple Ion Implantation Effects on Wear and Wet Ability of Polyethylene Based Polymers (L Torrisi et al.); and other papers. Readership: Graduate students, academics, researchers and industrialists in laser and plasma physics." This book examines the theory and applications of laser-induced plasmas. Topics discussed include the application of laser-induced plasma expansion models for thin film deposition; cluster-containing plasma fumes for high-order harmonic generation laser radiation; pulsed laser deposition of nanocrystalline V2O5 thin films; nanosecond and femtosecond laser ablation of TeO2 crystals; resonant harmonic generation of short pulse laser in plasma and the influence of the heterogeneous nature of laser ablation on near-surface plasma formation and propagation. This book represents the first comprehensive treatment of the subject, covering the theoretical principles, present experimental status and important applications of short-pulse laser-matter interactions. Femtosecond lasers have undergone dramatic technological advances over the last fifteen years, generating a whole host of new research activities under the theme of ?ultrafast science?. The focused light from these devices is so intense that ordinary matter is torn apart within a few laser cycles. This book takes a close-up look at the exotic physical phenomena which arise as a result of this new form of ?light-matter? interaction, covering a diverse set of topics including multiphoton ionization, rapid heatwaves, fast particle generation and relativistic self-channeling. These processes are central to a number of exciting new applications in other fields, such as microholography, optical particle accelerators and photonuclear physics. "Laser produced plasma provides a basis for many emerging technologies because it can interact with photons and charged particles in powerful and unique ways. These laser-plasma-based applications frequently rely on the controlled coupling of the laser pulse to the plasma to achieve the desired effects. Spatiotemporal (ST) pulse shaping, referring to the intentional correlation of the spatial and temporal characteristics of the laser pulse, can enhance control over the laser-plasma coupling improving the utility of laser-plasma-based applications. This work presents the basic theory of two ST shaping techniques, the chromatic flying focus (CFF) [D.H. Froula et al., "Spatiotemporal control of laser intensity" Nature Photonics 12, 262?265 (2018), D.H. Froula et al., "Flying focus: Spatial and temporal control of intensity for laser-based applications" Physics of Plasmas 26] and the ultrashort flying focus (UFF) ["Dephasingless Laser Wakefield Acceleration" Physical Review Letters 124, 134802 (2020)], and explores their applications experimentally and theoretically. Both techniques have at least three advantages in common: 1) laser pulse focusing is cylindrically symmetric, allowing high focused intensities to be reached, 2) the focal range is decoupled from the spot size, allowing high intensity to be maintained over long distances, and 3) the intensity peak velocity (focal velocity, v f) is decoupled from the laser group velocity, facilitating intensity peaks with tunable velocity. CFF pulses derived from the Multi-Terawatt laser at the Laboratory for Laser Energetics were used to drive ionization waves of arbitrary velocity (IWAVs) in air. These IWAVs, which are the moving interface between a neutral medium and an ionized plasma, moved at the focal velocity v f when driven by low energy pulses with uniform power spectra, agreeing with theoretical predictions. Focal velocity ranges shown computationally to mitigate ionization refraction were also confirmed [D. Turnbull et al., "Ionization Waves of Arbitrary Velocity" Physical Review Letters 120, 225001 (2018), J.P. Palastro et al., "Ionization waves of arbitrary velocity driven by a flying focus" Physical Review A 97, 033835 (2018)]. Later experiments demonstrated IWAVs of large diameter using defocused laser pulses in a gas jet. The non-uniform power spectrum of these higher energy pulses resulted in experimentally observable changes to the IWAV diameter and trajectory. An analytic theory predicting the IWAV trajectory and diameter for CFF pulses with non-uniform power spectra was developed, and broadly agreed with the experimental observations. This theory was used to propose the use of power spectrum shaping as a way to better tune the

IWAV characteristics [P. Franke et al., "Measurement and control of large diameter ionization waves of arbitrary velocity" Optics Express 27, 31978?31988 (2019)]. Photon acceleration, describing the continual frequency increase accrued by a photon in a time decreasing refractive index gradient as a means to generate extreme ultraviolet light, is an application shown computationally to be advanced by the generation of IWAVs. A computational investigation of three photon acceleration schemes enable by IWAVs is presented. A new optical shock-enhanced self-photon acceleration regime was identified using a finite-difference time-domain computational model. This regime, which is characterized by rapid spectral broadening and temporal compression of the drive laser pulse, could generate isolated attosecond pulses in the extreme ultraviolet with high efficiency [A.J. Howard et al., "Photon Acceleration in a Flying Focus" Physical Review Letters 123, 124801 (2019), P. Franke et al., "Optical shock-enhanced self-photon acceleration" Physical Review A 104, 043520 (2021)]. An experimental platform was developed to measure the UFF, and prototype radial echelon optics were manufactured. The echelon optics were fabricated using vapor-deposition through a rotating mask, and were measured to be suitable for initial experiments. An automated scanning spectral interferometer was built and benchmarked, then used to make initial measurements of the UFF. The UFF was not explicitly demonstrated, but several experimental shortcomings were identified, illuminating a path toward an ultimate demonstration. A successful demonstration of the UFF will immediately enable a series of experiments planned to study dephasingless laser wakefield acceleration and related topics"--Pages xi-xiii
Development of high power lasers opened a new era of scientific innovations. Now it is possible to study the matter properties under extreme conditions applicable to large number of potential applications. The field of laser-plasma interaction is very vast and wealthy in content. In this thesis we present three basic aspects related to the subject.We have developed a new model for laser interaction with solid targets which is applicable for the laser pulse duration ranging from femtoseconds to picoseconds. The benchmarking of the model is done by testing various special cases. The absorption model is coupled with one dimension radiation hydrodynamics, opacity and equation of state data in order to simulate various experiments. The interaction of laser with atomic cluster is also investigated in this monograph. A new hydrodynamic model for laser cluster interaction is presented. Our model takes into account the radial non-uniformity of the expanding cluster under the influence of

incident laser. Finally the laser induced ion acceleration is also studied using one dimensional particle-in-cell code. This thesis establishes an exciting new beginning for Laser Plasma Accelerators (LPAs) to further develop toward the next generation of compact high energy accelerators. Design, installation and commissioning of a new experimental setup at LBNL played an important role and are detailed through three critical components: e-beam production, reflection of laser pulses with a plasma mirror and large wake excitation below electron injection threshold. Pulses from a 40 TW peak power laser system were split into a 25 TW pulse and a 15 TW pulse. The first pulse was used for e-beam production in the first module and the second pulse was used for wake excitation in the second module to post-accelerate the e-beam. As a result, reliable e-beam production and efficient wake excitation necessary for the staged acceleration were independently demonstrated. These experiments have laid the foundation for future staging experiments at the 40 TW peak power level. This book focuses on the physics of laser plasma interactions and presents a complementary and very useful numerical model of plasmas. It describes the linear theory of light wave propagation in plasmas, including linear mode conversion into plasma waves and collisional damping.