

Super-Intense Laser-Atom Physics

Edited by

Bernard Piraux and Kazimierz Rzążewski

NATO Science Series

Super Intense Laser Atom Physics Nato Science Series Ii

Miguel Marques

Super Intense Laser Atom Physics Nato Science Series Ii:

Super-Intense Laser-Atom Physics Bernard Piraux, Kazimierz Rzazewski, 2001-03-31 The study of atomic systems exposed to super intense laser fields de fines an important area in atomic molecular and optical physics Although the concept of super intense field has no absolute meaning it is now usual to call an electromagnetic field super intense when it exceeds the atomic binding field In the case of the simplest atomic system hydrogen in its 16 2 ground state this occurs above an intensity of 3 5 x 10 Wattfcm which is the atomic unit of intensity Presently at the laboratory scale and in ex tremely short and tightly focussed laser pulses the electric field strength 16 18 2 reaches peak values which are of the order of 10 10 Wattfcm in the infrared frequency regime the prospect being that such peak intensities may be reached within a few years in a regime of much higher frequencies XUV or even X The interaction of such electromagnetic fields with an atomic system has a highly non linear character which has led to the observation of to tally unexpected phenomena There are three fundamental processes which have marked the beginning of an intensive research in the field of super intense laser atom physics SILAP These processes which only involve one atomic electron are i the so called above threshold ionisation i e Laser—Atom Physics A. L'Huillier, Bernard Piraux, Kazimierz Rzazewski, 2012-12-06 The rapid development of powerful pulsed lasers is at the origin of a conside rable interest in studying the response of an atom a molecule or a solid to a strong electromagnetic field It is now possible to produce at the laboratory scale ultra short 13 pulses with a duration of 100 femtoseconds 10 second and a power of the order 12 of 1 terawatt 10 Watt Under these conditions very high peak intensities may be obtained and electric fields exceeding typical electron binding fields in atoms are generated The interaction of an atom or a molecule with such electromagnetic fields has a highly non linear character which leads to unexpected phenomena Amongst them above threshold ionization ATI i e the absorption of additional photons in excess of the minimal number necessary to overcome the ionization potential and its molecular counterpart above threshold dissociation ATD generation of very high harmonics of the driving field stabilization of one electron systems in strong fields These processes were the main topics of two international meetings which were held in 1989 and 1991 in the United States under the common name SILAP Super Intense Laser Atom Physics **Super-Intense Laser-Atom Physics IV** H.G. Muller, M.V. Fedorov, 1996-05-31 Atoms in strong radiation fields are interesting objects for study and the research field that concerns itself with this study is a comparatively young one For a long period after the scovery of the photoelectric effect it was not possible to generate electro magnetic fields that did more than perturb the atom only slightly and first or er perturbation theory could perfectly explain what was going on at those low intensities The development of the pulsed laser bas changed this state of affairs in a rather dramatic way and fields can be applied that really have a large or even dominant influence on atomic structure In the latter case w speak of super intense fields Since the interaction between atoms and electromagnetic waves is characterized by many parameters other than the light intensity such as frequency iQnization potential orbit time etc it is actually quite

difficult to define what is exactly meant by the term super intense Obviously the term does not have an absolute meaning and intensity should always be viewed in relation to other properties of the system An atom in a radiation field can thus best be described in terms of various ratios of the quantities involved. The nature of the system sometimes drastically changes if the value of one of these parameters exceeds a certain critical value and the new regime could be called super intense with respect to that parameter Advances in Atomic, Molecular, and Optical Physics, 2012-10-18 Advances in Atomic Molecular and Optical Physics publishes reviews of recent developments in a field which is in a state of rapid growth as new experimental and theoretical techniques are used on many old and new problems Topics covered include related applied areas such as atmospheric science astrophysics surface physics and laser physics Articles are written by distinguished experts and contain both relevant review material and detailed descriptions of important recent developments International experts Comprehensive articles New developments Springer Handbook of Atomic, Molecular, and Optical Physics Gordon W. F. Drake, 2023-02-09 Comprises a comprehensive reference source that unifies the entire fields of atomic molecular and optical AMO physics assembling the principal ideas techniques and results of the field 92 chapters written by about 120 authors present the principal ideas techniques and results of the field together with a guide to the primary research literature carefully edited to ensure a uniform coverage and style with extensive cross references Along with a summary of key ideas techniques and results many chapters offer diagrams of apparatus graphs and tables of data From atomic spectroscopy to applications in comets one finds contributions from over 100 authors all leaders in their respective disciplines Substantially updated and expanded since the original 1996 edition it now contains several entirely new chapters covering current areas of great research interest that barely existed in 1996 such as Bose Einstein condensation quantum information and cosmological variations of the fundamental constants A fully searchable CD ROM version of the contents accompanies the handbook Super-Intense Laser-Atom Physics Bernard Piraux, Kazimierz Rzazewski, 2001-03-31 The study of atomic systems exposed to super intense laser fields de fines an important area in atomic molecular and optical physics Although the concept of super intense field has no absolute meaning it is now usual to call an electromagnetic field super intense when it exceeds the atomic binding field In the case of the simplest atomic system hydrogen in its 16 2 ground state this occurs above an intensity of 3 5 x 10 Wattfcm which is the atomic unit of intensity Presently at the laboratory scale and in ex tremely short and tightly focussed laser pulses the electric field strength 16 18 2 reaches peak values which are of the order of 10 10 Wattfcm in the infrared frequency regime the prospect being that such peak intensities may be reached within a few years in a regime of much higher frequencies XUV or even X The interaction of such electromagnetic fields with an atomic system has a highly non linear character which has led to the observation of to tally unexpected phenomena There are three fundamental processes which have marked the beginning of an intensive research in the field of super intense laser atom physics SILAP These processes which only involve one atomic electron are i the so called above threshold ionisation i e

Atomic and Molecular Spectroscopy Sune Syanberg, 2012-12-06 Atomic and Molecular Spectroscopy is a wide ranging review of modern spectroscopic techniques such as X ray photoelectron optical and laser spectroscopy as well as radiofrequency and microwave techniques On the fundamental side it focuses on physical principles and the impact of spectroscopy on our understanding of the building blocks of matter while in the area of applications particular attention is paid to chemical analysis photochemistry surface characterisation environmental and medical diagnostics remote sensing and astrophysics The third edition also provides the reader with an update on laser cooling and trapping Bose Einstein condensation ultrafast spectroscopy high power laser matter interaction satellite based astronomy and spectroscopic aspects Quantum Systems in Chemistry and Physics. Trends in Methods and Applications R. McWeeny, Jean Maruani, Y.G. Smeyers, S. Wilson, 1998-01-31 Quantum Systems in Chemistry and Physics contains a refereed selection of the papers presented at the first European Workshop on this subject held at San Miniato near Pisa Italy in April 1996 The Workshop brought together leading experts in theoretical chemistry and molecular physics with an interest in the quantum mechanical many body problem This volume provides an insight into the latest research in this increasingly important field Throughout the Workshop the emphasis was on innovative theory and conceptual developments rather than on computational implementation The various contributions presented reflect this emphasis and embrace topics such as density matrices and density functional theory relativistic formulations electron correlation valence theory nuclear motion response theory condensed matter and chemical reactions Audience The volume will be of interest to those working in the molecular sciences and to theoretical chemists and molecular physicists in particular The British National Bibliography Arthur James Time-Dependent Density Functional Theory Miguel Marques, 2006-08-14 Time dependent density functional Wells.2001 theory TDDFT is based on a set of ideas and theorems quite distinct from those governing ground state DFT but emphasizing similar techniques Today the use of TDDFT is rapidly growing in many areas of physics chemistry and materials sciences where direct solution of the Schr dinger equation is too demanding This is the first comprehensive textbook style introduction to the relevant basics and techniques Advances in Atomic, Molecular, and Optical Physics Benjamin Bederson, Herbert Walther, 2002-12-09 This series established in 1965 is concerned with recent developments in the general area of atomic molecular and optical physics The field is in a state of rapid growth as new experimental and theoretical techniques are used on many old and new problems Topics covered include related applied areas such as atmospheric science astrophysics surface physics and laser physics Articles are written by distinguished experts who are active in their research fields The articles contain both relevant review material and detailed descriptions of important recent developments Atoms, Solids, and Plasmas in Super-Intense Laser Fields Dimitri Batani, Charles J. Joachain, S. Martellucci, Arthur N.

Atoms, Solids, and Plasmas in Super-Intense Laser Fields Dimitri Batani, Charles J. Joachain, S. Martellucci, Arthur N. Chester, 2012-12-06 The recent developement of high power lasers delivering femtosecond pulses of 20 2 intensities up to 10 W cm has led to the discovery of new phenomena in laser interactions with matter At these enormous laser intensities atoms

and molecules are exposed to extreme conditions and new phenomena occur such as the very rapid multi photon ionization of atomic systems the emission by these systems of very high order harmonics of the exciting laser light the Coulomb explosion of molecules and the acceleration of electrons close to the velocity of light These phenomena generate new behaviour of bulk matter in intense laser fields with great potential for wide ranging applications which include the study of ultra fast processes the development of high frequency lasers and the investigation of the properties of plasmas and condensed matter under extreme conditions of temperature and pressure In particular the concept of the fast ignitor approach to inertial confinement fusion ICF has been proposed which is based on the separation of the compression and the ignition phases in laser driven ICF The aim of this course on Atom Solids and Plasmas in Super Intense Laser fields was to bring together senior researchers and students in atomic and molecular physics laser physics condensed matter and plasma physics in order to review recent developments in high intensity laser matter interactions The course was held at the Ettore Majorana International Centre for Scientific Culture in Erice from July 8 to July 14 2000 **Physics with Multiply Charged Ions** Dieter Liesen, 2013-06-29 Multiply charged ions have always been in the focus of atomic physics astrophysics plasma physics and theoretical physics Within the last few years strong progress has been achieved in the development of ion sources ion storage rings ion traps and methods to cool ions As a consequence nowadays experiments with ensembles of multiply charged ions of brilliant quality are performed in many laboratories. The broad spectrum of the experiments demonstrates that these ions are an extremely versatile tool for investigations in pure and applied physics It was the aim of this ASI to bring together scientists working in different fields of research with multiply charged ions in order to get an overview of the state of the art to sound out possibilities for fruitful cooperations and to discuss perspectives for the future Accordingly the programme of the ASI reached from established areas like QED calculations weak interactions x ray astronomy x ray lasers multi photon excitation heavy ion induced fusion and ion surface interactions up to the very recently opened areas like bound beta decay laser and x ray spectroscopy and spectrometry of ions in rings and traps and the interaction of highly charged ions with biological cells Impressive progress in nearly all of the fields could be reported during the meeting which is documented by the contributions to this volume The theoretical understand ing of QED and correlation effects in few electron heavy ions is rapidly developing American Book Publishing Record, 2001 **High-Performance Computing R.J.** Allan, M.F. Guest, A.D. Simpson, D.S. Henty, D. Nicole, 2012-12-06 Over the past decade high performance computing has demonstrated the ability to model and predict accurately a wide range of physical properties and phenomena Many of these have had an important impact in contributing to wealth creation and improving the quality of life through the development of new products and processes with greater efficacy efficiency or reduced harmful side effects and in contributing to our ability to understand and describe the world around us Following a survey ofthe U K s urgent need for a supercomputingfacility for aca demic research see next chapter a 256 processor T3D system from Cray Research Inc went into operation at the

University of Edinburgh in the summer of 1994 The High Performance Computing Initiative HPCI was established in November 1994 to support and ensure the efficient and effective exploitation of the T3D and future gen erations of HPC systems by a number of consortia working in the frontier areas of computational research The Cray T3D now comprising 512 processors and total of 32 CB memory represented a very significant increase in computing power allowing simulations to move forward on a number offronts The three fold aims of the HPCI may be summarised as follows 1 to seek and maintain a world class position incomputational scienceand engineering 2 to support and promote exploitation of HPC in industry commerce and business and 3 to support education and training in HPC and its application Electron Correlations and Materials Properties A. Gonis, Nicholis Kioussis, Mikael Ciftan, 2012-12-06 Over the last thirty years or so the attempts to identify the electronic origins of materials properties have proceeded along two distinct and apparently divergent methodologies On the one hand so called single particle methods are based on the study of a single electron moving in an effective field formed by the other electrons and the nuclei in the system Band theory as this approach is referred to has had impressive successes in determining the equilibrium properties such as structural stability volume and charge densities of specific materials notably metals Today even coherent phase diagrams based on a single underlying lattice for binary metallic alloys can be studied with considerable accuracy In spite of its serious and well understood limitations regarding the handling of correlations band theory has been embraced by the materials scientist Its single particle nature endows the method with an economy of concepts which leads to a clear identification of mechanisms driving physical behavior at the electronic level This perceived clarity often tends to override legitimate concerns regarding the validity of the method or its ability to correctly identify the mechanisms in the first place The alternative methodology pursued in the study of quantum systems consists of what can be referred to as conventional many body theory. This methodology is based on attempts to study explicitly the effects of interparticle correlations using a number of different formal approaches including but not limited to perturbation methods Green function equation of motion methods configuration interactions quantum Monte Carlo Laser Interactions with Atoms, Solids and Plasmas Richard M. More, 2013-11-21 The aim of this NATO and others Advanced Study Institute was to bring together scientists and students working in the field of laser matter interactions in order to review and stimulate development of fundamental science with ultra short pulse lasers New techniques of pulse compression and colliding pulse mode locking have made possible the construction of lasers with pulse lengths in the femtosecond range Such lasers are now in operation at several research laboratories in Europe and the United States These laser facilities present a new and exciting research direction with both pure and applied science components In this ASI the emphasis is on fundamental processes occurring in the interaction of short laser pulses with atoms molecules solids and plasmas In the case of laser atom molecule interactions high power lasers provide the first access to extreme high intensity conditions above 10 8 Watts em a new frontier for nonlinear interaction of photons with atoms and molecules New

phenomena observed include multiphoton ionization processes atomic collisions in the presence of a strong laser field Coulomb explosion following rapid ionization of a molecule and the production of high harmonics of the laser source Another **Optical Technologies for Extreme-Ultraviolet and** important topic reviewed in this ASI is the lasercooling of atoms **Soft X-ray Coherent Sources** Federico Canova, Luca Poletto, 2015-08-17 The book reviews the most recent achievements in optical technologies for XUV and X ray coherent sources Particular attention is given to free electron laser facilities but also to other sources available at present such as synchrotrons high order laser harmonics and X ray lasers The optical technologies relevant to each type of source are discussed In addition the main technologies used for photon handling and conditioning namely multilayer mirrors adaptive optics crystals and gratings are explained Experiments using coherent light received during the last decades a lot of attention for the X ray regime Strong efforts were taken for the realization of almost fully coherent sources e g the free electron lasers both as independent sources in the femtosecond and attosecond regimes and as seeding sources for free electron lasers and X ray gas lasers In parallel to the development of sources optical technologies for photon handling and conditioning of such coherent and intense X ray beams advanced New problems were faced for the realization of optical components of beamlines demanding to manage coherent X ray photons e q the preservation of coherence and time structure of ultra short pulses **Many-Particle Quantum Dynamics in Atomic and Molecular Fragmentation** Joachim Ullrich, V.P. Shevelko, 2013-06-29 This book aims to give a comprehensive view on the present status of a tremendously fast developing field the quantum dynamics of fragmenting many particle Coulomb systems In striking contrast to the profound theo retical knowledge achieved from extremely precise experimental results on the static atomic and molecular structure it was only three years ago when the three body fundamental dynamical problem of breaking up the hydro gen atom by electron impact was claimed to be solved in a mathematically consistent way Until now more complicated though still fundamental scenarios ad dressing the complete fragmentation of the simplest many electron system the helium atom under the action of a time dependent external force have withstood any consistent theoretical description Exceptions are the most trivial situations where the breakup is induced by the impact of a single real photon or of a virtual photon under a perturbation caused by fast low charged particle impact Similarly the dissociation of the simplest molecu lar systems like Ht or HD fragmentating in collisions with slow electrons or the H3 molecule breaking apart into two or three pieces as a result of a single laser photon excitation establish a major challenge for state of the art theoretical <u>High-Intensity X-rays - Interaction with Matter</u> Stefan P. Hau-Riege, 2012-09-19 Filling the need for a book approaches bridging the effect of matter on X ray radiation and the interaction of x rays with plasmas this monograph provides comprehensive coverage of the topic As such it presents and explains such powerful new X ray sources as X ray free electron lasers as well as short pulse interactions with solids clusters molecules and plasmas and X ray matter interactions as a diagnostic tool Equally useful for researchers and practitioners working in the field

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