



# Super-Intense Laser-Atom Physics IV

Edited by

H. G. Muller and M. V. Fedorov

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# Super Intense Laser Atom Physics

**Marcelo Ciappina, Paraskevas Tzallas**



## **Super Intense Laser Atom Physics:**

**Super-Intense 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 considerable 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 discovery 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 has 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 **Super-Intense Laser-Atom Physics** Bernard Piraux, Kazimierz Rzazewski, 2001-04-14 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  $3.5 \times 10^{16}$  Watt/cm<sup>2</sup> 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  $10^{10}$  Watt/cm<sup>2</sup> 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 totally 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 the so called above threshold ionisation i e

**Super-Intense Laser-Atom Physics** Bernard Piraux,Kazimierz

Rzazewski,2001-03-31 The study of atomic systems exposed to super intense laser fields defines 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  $3.5 \times 10^{16}$  W/cm<sup>2</sup> which is the atomic unit of intensity Presently at the laboratory scale and in extremely short and tightly focussed laser pulses the electric field strength 16 18 2 reaches peak values which are of the order of  $10^{10}$  W/cm<sup>2</sup> 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 totally 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 the so called above threshold ionisation i e

*NATO Advanced Research Workshop on Super-Intense Laser-Atom Physics*

NATO.,OTAN.,1993 **Atoms, Solids, and Plasmas in Super-Intense Laser Fields** Dimitri Batani,2001-09-30

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 **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 **Atoms, Solids, and Plasmas in Super-Intense Laser Fields** Dimitri Batani,Charles J. Joachain,S.

Martellucci,Arthur N. Chester,2012-12-06 The recent development of high power lasers delivering femtosecond pulses of 20

2 intensities up to  $10 \text{ W cm}^{-2}$  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. Request for Support for the Conference on Super Intense Laser Atom Physics, 2004. The Conference on Super Intense Laser Atom Physics (SILAP) was held in November 2003 in Dallas, Texas. The venue for the meeting was South Fork Ranch in the outskirts of Dallas. The topics of the meeting included high harmonic generation and attosecond pulse generation, strong field interactions with molecules and clusters, particle acceleration and relativistic laser-atom interactions. *Atoms in Intense Laser Fields* C. J. Joachain, N. J. Kylstra, R. M. Potvliege, 2012. A unified account of the rapidly developing field of high intensity laser-atom interactions suitable for both graduate students and researchers. **Advances in Multi-Photon Processes and Spectroscopy** S. H. Lin, 2008. This book presents the latest developments and issues in both experimental and theoretical studies of multi-photon processes and the spectroscopy of atoms, ions and molecules in physics, chemistry, biology and material science. It contains review papers suitable for both active researchers and non-experts who wish to enter the field. Special attention is paid to the recent progress of non-linear photon-matter interactions in atoms, molecules and interfaces, XUV, soft X-ray, high order harmonic generation in attosecond regime, high order harmonic generation, sum frequency generation, four-wave mixing, spectroscopy and molecular orientation with combined electrostatic and intense non-resonant laser fields. **Big Sky Workshop on Super-Intense Laser-Atom Physics Held in Big Sky, Montana on 22-25 June 1991**, 1992. A Workshop was convened in order to examine and discuss current theoretical understanding of the interaction of very high intensity short pulse laser light with material systems and to assess the possibility of experimental study of new theoretical predictions. In order to provide a specific focus, attention was restricted to new aspects of single electron phenomena in strong and super strong laser fields. Big Sky Workshop on Super-Intense Laser-Atom Physics Held in Big Sky, Montana on 22-25 1991, 1992. The workshop on super intense laser atom physics consisted of 22 invited talks and 32 presentations in the poster

session     *Handbook of Laser Technology and Applications* Chunlei Guo,2021-05-10 This comprehensive handbook gives a fully updated guide to lasers and laser technologies including the complete range of their technical applications The first volume outlines the fundamental components of lasers their properties and working principles Key Features Offers a complete update of the original bestselling work including many brand new chapters Deepens the introduction to fundamentals from laser design and fabrication to host matrices for solid state lasers energy level diagrams hosting materials dopant energy levels and lasers based on nonlinear effects Covers new laser types including quantum cascade lasers silicon based lasers titanium sapphire lasers terahertz lasers bismuth doped fiber lasers and diode pumped alkali lasers Discusses the latest applications e g lasers in microscopy high speed imaging attosecond metrology 3D printing optical atomic clocks time resolved spectroscopy polarization and profile measurements pulse measurements and laser induced fluorescence detection Adds new sections on laser materials processing laser spectroscopy lasers in imaging lasers in environmental sciences and lasers in communications This handbook is the ideal companion for scientists engineers and students working with lasers including those in optics electrical engineering physics chemistry biomedicine and other relevant areas

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 and others     Time-Dependent Density Functional Theory Miguel A.L. Marques,Carsten A. Ullrich,Fernando Nogueira,Angel Rubio,Kieron Burke,Eberhard K. U. Gross,2006-09-12 The year 2004 was a remarkable one for the growing eld of time dependent density functional theory TDDFT Not only did we celebrate the 40th niversary of the Hohenberg Kohn paper which had laid the foundation for ground state density functional theory DFT

but it was also the 20th anniversary of the work by Runge and Gross establishing a firm footing for the time dependent theory. Because the field has grown to such prominence and has spread to so many areas of science from materials to biochemistry we feel that a volume dedicated to TDDFT is most timely. TDDFT is based on a set of ideas and theorems quite distinct from those governing ground state DFT but employing similar techniques. It is far more than just applying ground state DFT to time dependent problems as it involves its own exact theorems and new and different density functionals. Presently the most popular application is the extraction of electronic excited state properties especially transition frequencies. By applying TDDFT after the ground state of a molecule has been found we can explore and understand the complexity of its spectrum thus providing much more information about the species. TDDFT has an especially strong impact in the photochemistry of biological molecules where the molecules are too large to be handled by traditional quantum chemical methods and are too complex to be understood with simple empirical frontier orbital theory.

**High-order Harmonic Generation In Solids** Marcelo Ciappina, Paraskevas Tzallas, 2024-06-11 High order harmonics emerging from the interaction of strong laser fields with solid matter constitute a novel highly sensitive tool for interrogating electronic structure and dynamics in solids. At the interface of attosecond physics and condensed matter physics this book provides an excellent overview of the current state of the art. Ferenc Krausz Nobel Laureate in Physics 2023 High order harmonic generation HHG in solids the nonlinear upconversion of coherent radiation resulting from the interaction of a strong and short laser pulse with bulk matter has come of age. Since the seminal experiments and theoretical developments there has been a constant and vibrant interest in this topic. In this book we invite experimental and theoretical experts in the field with the aim to summarize the progress made so far and propose new possibilities and prospects for the generation of high order harmonics using solid samples. Nowadays it is possible to engineer both spatially and temporally with nanometric and attosecond resolution the driven fields. This could bring solid HHG to the next exciting frontier as novel and fully tunable table top coherent sources.

**High Performance Computing in Science and Engineering '98** Egon Krause, Willi Jäger, 2012-12-06 The book contains reports about the most significant projects from science and industry that are using the supercomputers of the Federal High Performance Computing Center Stuttgart HLRS. These projects are from different scientific disciplines with a focus on engineering physics and chemistry. They were carefully selected in a peer review process and are showcases for an innovative combination of state of the art physical modeling, novel algorithms and the use of leading edge parallel computer technology. As HLRS is in close cooperation with industrial companies special emphasis has been put on the industrial relevance of results and methods.

**Future Energy Conferences and Symposia**, 1995 *Handbook of Optics, Third Edition Volume IV: Optical Properties of Materials, Nonlinear Optics, Quantum Optics (set)* Michael Bass, Casimer DeCusatis, Jay M. Enoch, Vasudevan Lakshminarayanan, Guifang Li, Carolyn MacDonald, Virendra N. Mahajan, Eric Van Stryland, 2009-10-06 The most comprehensive and up to date optics resource available. Prepared under the auspices of the Optical Society of America the

five carefully architected and cross referenced volumes of the Handbook of Optics Third Edition contain everything a student scientist or engineer requires to actively work in the field From the design of complex optical systems to world class research and development methods this definitive publication provides unparalleled access to the fundamentals of the discipline and its greatest minds Individual chapters are written by the world s most renowned experts who explain illustrate and solve the entire field of optics Each volume contains a complete chapter listing for the entire Handbook extensive chapter glossaries and a wealth of references This pioneering work offers unprecedented coverage of optics data techniques and applications Volume IV covers optical properties of materials nonlinear optics and quantum optics

## Unveiling the Energy of Verbal Beauty: An Mental Sojourn through **Super Intense Laser Atom Physics**

In a world inundated with displays and the cacophony of quick connection, the profound power and mental resonance of verbal art often disappear into obscurity, eclipsed by the continuous assault of sound and distractions. Yet, located within the musical pages of **Super Intense Laser Atom Physics**, a interesting perform of fictional brilliance that pulses with natural feelings, lies an unique journey waiting to be embarked upon. Published by a virtuoso wordsmith, that interesting opus courses readers on a psychological odyssey, softly exposing the latent possible and profound influence embedded within the intricate web of language. Within the heart-wrenching expanse with this evocative examination, we can embark upon an introspective exploration of the book is key subjects, dissect its captivating publishing type, and immerse ourselves in the indelible impact it leaves upon the depths of readers souls.

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