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Progress in Ultrafast Intense Laser Science

Volume I

With 162 Figures

Springer

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Preface

Light and Optical Science have undoubtedly deepened our understanding of nature. The history of science shows that each invention of a new optical technique and research instrument has spurred new discoveries in various disciplines. Of particular importance is laser radiation, discovered in 1960, which opened up new research fields. Later, key technologies such as modelocking and chirped-pulse-amplification have accelerated the development and initiated the era of optical science in which pulses as short as a few femtoseconds are commonly used while subfemtosecond pulses are rapidly coming of age.

Such ultrashort pulses have enabled the generation of extremely intense light fields whose magnitude can far exceed that of the atomic Coulomb field. Thus, light, which had long been used only as a probe for matter, has now achieved such huge intensity that it can strongly distort atomic and molecular quantum states. That is, the character of light-matter interaction becomes qualitatively different from that in the weak light field regime. New tools for controlling and fine-designing ultrashort laser pulses have introduced entirely new possibilities for controlling the dynamics of atoms and molecules. Indeed, the response of matter to an ultrashort intense laser field has been a very exciting and challenging subject of research from the beginning, and exceedingly so during the past 15 years.

During this period, tremendous advances have been achieved both in fundamental understanding and practical applications. For instance, the irradiation of liquid and solid materials by intense laser light generates short pulses of hard-X rays as well as high-energy electrons, ions and neutrons, which are now regarded as promising sources for time-resolved measurements. The interaction between gaseous media and ultrashort intense laser pulses induces quite remarkable phenomena such as filamentation, plasma formation, and high-order harmonic generation. The latter forms the basis of tabletop soft X-ray sources and of the Fourier synthesis of "attosecond" light pulses, the shortest light pulses ever made.

The research field of ultrafast intense laser science, clustering both the fundamental and applied aspects of ultrashort (femtosecond to attosecond), intense (10^{14} to $10^{18}\,\mathrm{Wcm}^{-2}$) pulses, is now rapidly growing worldwide, not only in physics (nonlinear optics, time-resolved ultrafast X-ray spectroscopy, metrology, non-linear physics) and chemistry (physical chemistry, molecular

science) but also in biology. It is, therefore, much desired that researchers and students in an even wider range of research fields share the enthusiasm for this provocative interdisciplinary research field.

It is with this hope that a new series of symposia called "International Symposium on Ultrafast Intense Laser Science (ISUILS)" was launched in 2002 (http://www.isuils.jp). These very successful meetings have encouraged us to pursue the diffusion of ultrafast intense laser science under another form. This is the origin of the present series. Considering the interdisciplinary nature of Ultrafast Intense Laser Science, we thought it appropriate to complement the ISUILS symposia with a new review book series, in which concise review-style articles written by researchers at the forefront of their sub-fields are compiled, so that researchers with different research backgrounds and graduate students could grasp easily the essential aspects of the corresponding field. Although conference proceedings may be useful for researchers with specific interests, and long and complete review articles are necessary for researchers interested in a specific theme, there is room for a new style of review articles more fitted to the interdisciplinary interaction in UILS and the rapidly growing character of the field.

The research areas treated in this series will be: (i) atoms, molecules, and clusters in intense laser fields, (ii) control of molecules and clusters in intense laser fields, (iii) attosecond pulse generation, metrology, and applications, (iv) wavepacket control for high-order harmonics, (v) generation, metrology and interaction of intense few-cycle pulses, (vi) non-linear dynamics in chaotic tunneling for understanding ionization in intense laser fields, (vii) non-linear propagation and fs-ablation, (viii) short-pulsed laser plasma interaction, (ix) non-linear optics in nano plasmas, (x) X-ray imaging, (xi) short-pulsed electron diffraction, (xii) nuclear transitions in laser fields, (xiii) relativistic quantum dynamics, (xiv) laser pulse interaction with materials having nano structure, (xv) femtosecond biology.

Each book of the new series addresses such needs through a compilation of around fifteen 15–25 page chapters. All chapters are written with the goal of providing researchers with a different expertise a clear assessment of the motivation and significance of the research theme as well as a description of the authors' most recent results. The editors hope that the reader will find, in this first volume, not only answers to specific questions but also insights into other subfields and new perspectives for his/her own future research.

Invitations to contribute have been extended to the invited participants of the first three ISUILS symposia. Hence, the first three or four volumes of PUILS will be by invitation only. The PUILS series has been edited in cooperation with the activities of MEXT Priority Area Program on Control of Molecules in Intense Laser Fields (FY2002–2005), JSPS Core-to-Core Program on Ultrafast Intense Laser Science (FY2004–) and JILS (Japan Intense Light Field Science Society).

We take this opportunity to thank all the authors who have kindly contributed to the new PUILS series by describing frontiers of ultrafast intense laser science. We also thank reviewers who have served for this book project by reading carefully the submitted manuscripts. One of the co-editors (KY) thanks Ms. Miyuki Kusunoki and Ms. Chie Sakuta for their help with the editing processes. Dr. Claus Ascheron, Physics Editor of Springer Verlag at Heidelberg kindly agreed to our idea and helped us co-edit the first volume of PUILS. We very much appreciate his kind cooperation and support. We hope this book series of PUILS will convey the excitement of Ultrafast Intense Laser Science to the readers, and stimulate interdisciplinary interactions among researchers, thus paving the way for explorations of new frontiers.

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March, 2006

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