

# Preface

Undoubtedly the progress of Molecular Sciences has benefited from the *strong interaction* with ultrafast laser techniques and developments in the last decades. In many instances, ultrafast lasers have been employed along with technological advances as a tool to study molecular systems with the aim to understand their time evolution and, in general, to disentangle the time-resolved behavior of matter. The main idea behind the scene is to reach the time scales where molecular processes occur and to visualize their time evolution; that is, femtoseconds for nuclear motion and attoseconds for electronic motion. Interesting new phenomena have emerged however when this strong interaction between ultrashort ultraintense light and molecules has been provoked, and this has stimulated in turn new developments both experimental and theoretical to try to understand the new phenomena. This loop between applications and the appearance of new phenomena is behind the progress of the field.

This volume of Springer Series in Chemical Physics is conceived to cover the latest progress on the applications of Ultrafast Technology to Molecular Sciences, from small molecules to proteomics and molecule-surface interactions, and from conventional femtosecond laser pulses and pump-probe and charged particle detection techniques to attosecond pulses in the XUV. The attosecond and few-cycle femtosecond applications are covered in the first Chapter written by Marc Vrakking and co-workers (Chap. 1), where the measurement of molecular frame photoelectron angular distributions of high kinetic energy photoelectrons for small molecules brings the time evolution of molecular structures in the course of a photochemical event. The theoretical aspects along these lines come from the Chapter written by Fernando Martin and his co-workers (Chap. 2) focusing on a simple molecular system, the hydrogen molecule, where state-of-the-art time-dependent theoretical methods are able to provide a solid groundwork for describing and interpreting the underlying molecular dynamics observed experimentally. Larger molecules under ultraintense laser fields are presented in the Chapter written by Tomoya Okino and Kaoru Yamanouchi (Chap. 3), where coincident momentum charged-particle imaging measurements shed light into intense field induced hydrogen atom migration in small hydrocarbons. The combination between the femtosecond pump-probe technique

and charged-particle (ion or photoelectron) imaging detection with resonant or non-resonant fragment ionization is the subject covered by the following three Chapters, written by Rebeca de Nalda and Luis Bañares and their co-workers (Chap. 4), Helen Fielding and co-workers (Chap. 5) and Vasilios Stavros and co-workers (Chap. 6), where key applications to the photodynamics of polyatomic molecular systems are presented. Also theoretical support is crucial when studying such larger molecular systems, but in such cases accurate quantum mechanical treatments are intractable. In the Chapter written by Leticia González and Ignacio Solá and their co-workers (Chap. 7) an approach based on semiclassical methods to study the photodynamics of polyatomic molecular systems is presented. The extension to really large molecular systems is dealt with in the Chapter by Marcos Dantus and co-workers (Chap. 8), which is centered on femtosecond laser induced dissociation for proteomic analysis. Another aspect of photodynamics of excited states of biomolecules is the aim of the Chapter written by Marcus Motzkus and co-workers (Chap. 9). In this case, multidimensional time-resolved spectroscopy based on the non-linear broadband four-wave mixing technique using sub-20 femtosecond pulses is applied to address coherence and population dynamics in molecular excited states. Reaction dynamics in the gas-solid interface is treated in the Chapter written by Mihai Vaida and Thorsten Bernhardt (Chap. 10). In particular, the Chapter focuses on the dynamics of chemical reaction on metal oxide surfaces by using ultrashort laser pulses with a perspective to applications to photocatalytic reactions at supported metal clusters and nanoparticles. Finally, the Chapter written by Olivier Faucher and his co-workers (Chap. 11) centers on the use of non-linear coherent interactions of molecules with ultrashort laser pulses to deduce the properties of gas-phase molecules and to obtain information on the environment of molecules.

We thank all the authors for their valuable efforts to provide both a meaningful background and detailed descriptions of the research lines, and we hope that the material covered in this book provides an updated and insightful window into the broad range of areas where this field is evolving.

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