

Preface

The “Quantum Dynamic Imaging” workshop, the first of its kind ever held in Canada, focused on the theoretical and mathematical problems associated with the imaging of quantum phenomena in matter from the femtosecond (10^{-15} s) for nuclear motion to the attosecond (10^{-18} s) for electron motion. Motion of a proton, one of the most important nuclei in chemistry and biology (e.g., DNA) has a natural time scale of 7 femtoseconds. Motion of electrons, responsible for chemical binding and electron transfer processes in natural phenomena, has a characteristic time scale of about 100 attoseconds (it takes an electron 152 attoseconds to go around the hydrogen atom). Both proton and electron motion can only be described by quantum mechanics, i.e., high dimension partial differential equations (HDPDEs). Furthermore such motions can only be monitored by ultrashort laser pulses. Thus the interaction of matter with such pulses can only be described by HDPDEs such as time-dependent Schrödinger and Dirac (for relativistic phenomena) equations coupled to the photons (Maxwell equations).

The chapters of this book are based on lectures by invited speakers who are acknowledged experts in developing the necessary theories and numerical methods for treating photon-atom-molecule interactions in the nonlinear nonperturbative regime. In particular the generation of attosecond pulses is a spin-off of such theories of the nonlinear nonperturbative laser-matter interactions. The workshop was concerned with the mathematical problems and progress in developing and validating numerical methods used in the endeavor of imaging quantum phenomena with subfemtosecond temporal and sub-Angstrom spatial resolution. The experts addressed a very important problem of using quantum imaging methods discussed in the workshop and the massive amount of multidimensional information encoded in the time-dependent many-body wavefunctions for the eventual production of “molecular movies.” This is a new direction in molecular imaging with the aim of making quantum information available to researchers in the molecular sciences to visualize quantum phenomena on their natural, from the femto to attosecond, time scale.

The scientific publisher, Springer has agreed to publish the lectures of the invited speakers in the CRM Series in Mathematical Physics , under the title of the work-

shop. The co-organizers, who are co-editors of the book, wish to especially thank the CRM (Centre de recherches mathématiques—Montréal) staff for its dedication and invaluable help in making this workshop a success and in preparing this book.

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