

# Preface

This book is devoted to the theory of interactions between ultrashort electromagnetic pulses (USPs) and matter, including both the classical and quantum cases. This is a hot topic in modern physics thanks to significant progress in generating and shaping USPs over a wide range of carrier frequencies.

Special attention is given to the peculiarities of the USP–matter interaction, namely, the phase dependence of photoexcitation and the nonlinear dependence of the total process probability upon the USP duration for one- and sub-cycle USPs.

One of the important items in the book is the derivation and example applications of a simple new formula which describes the total photoprocess probability under the action of USPs in the framework of perturbation theory. This formula expresses the total probability in terms of the cross-section of the process in a monochromatic field and the Fourier transform of the electric field strength. It describes the phenomenon in the situation when the standard approach based on the concept of radiation intensity and process rate becomes inadequate. The resulting expression can be considered as the analog of the Fermi golden rule in the physics of ultrafast electromagnetic phenomena. The formula is used to describe the photoexcitation by USPs of atoms and optical centers in solids and also the scattering of USPs on atoms and in plasmas.

A significant place is devoted to the formalism of the optical Bloch vector, which gives a visual geometrical interpretation of radiative processes, making it possible to represent the time evolution of the quantum system under radiation through the rotation of a three-dimensional vector representing the state of the system. Strong field–matter interactions are treated using the Bloch formalism in a two-level approximation for USPs with variable characteristics, including chirped USPs.

The book is intended for a wide circle of readers, including students of the corresponding specialities, graduate students and scientists, university lecturers, and in fact anyone taking an interest in the physics of ultrafast electromagnetic interactions. It is hoped that representatives from each of the above groups will find useful material for their specific needs, whatever their scientific or pedagogic interests and qualifications.

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Matter

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