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Light-nanomatter interaction : basic theory and computational approach

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Interaction between light-fields and nano-scale objects has ever been an indispensable subject and a great source of researches in physical chemistry, chemical physics, laser physics, etc., that investigate matter with microscopic view points. The quantum state of nano-matter can be probed through the interaction with the light fields, enabling us to determine the atomic and molecular structure, as demonstrated in numerous spectroscopic measurements. It can further be altered or even largely changed with this interaction into a new quantum state, referred to as light-dressed state or simply dressed state, that is distinct from the inherent quantum structure through repetitive photon absorption and emission. This talk starts with an introduction of the confined electron systems called artificial atoms or quantum dots in which a small number of electrons are confined in a nano-scale potential well. These systems show unique properties with respect to the light-matter interaction since they can couple with light fields very strongly thanks to their huge oscillator strength as compared with 'natural' atoms and molecules with the same number of electrons. The origin of the appearance of this huge oscillator strength in artificial atoms will be discussed. The second part of the talk is concerned with the coupled Maxwell-Schroedinger approach. When an electron system is irradiated by an incident laser field, some of the electrons in the system having an excitation energy comparable to the photon energy are forced to move back-and-forth along the polarization axis of the incident field by its alternating electric field. Then, the accelerated electrons create a polarization current density which in turn goes into the Ampere-Maxwell equation and generates a new electromagnetic field in the vicinity of the electrons themselves. This new electromagnetic field can interfere with and thus update the original laser field. Implementation of this feedback effect from the excited electrons to the electromagnetic field in the computational framework will be discussed in detail.