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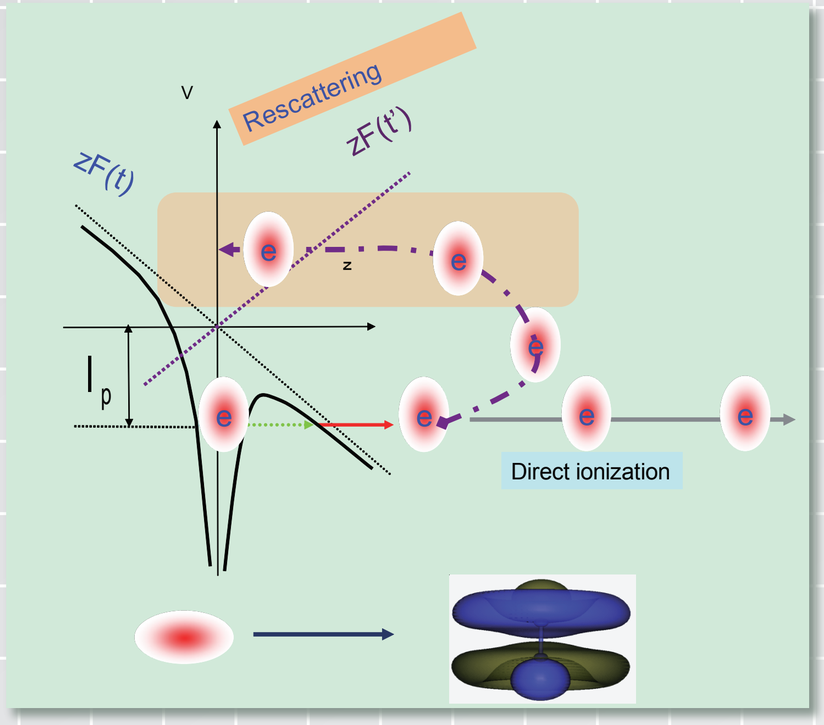
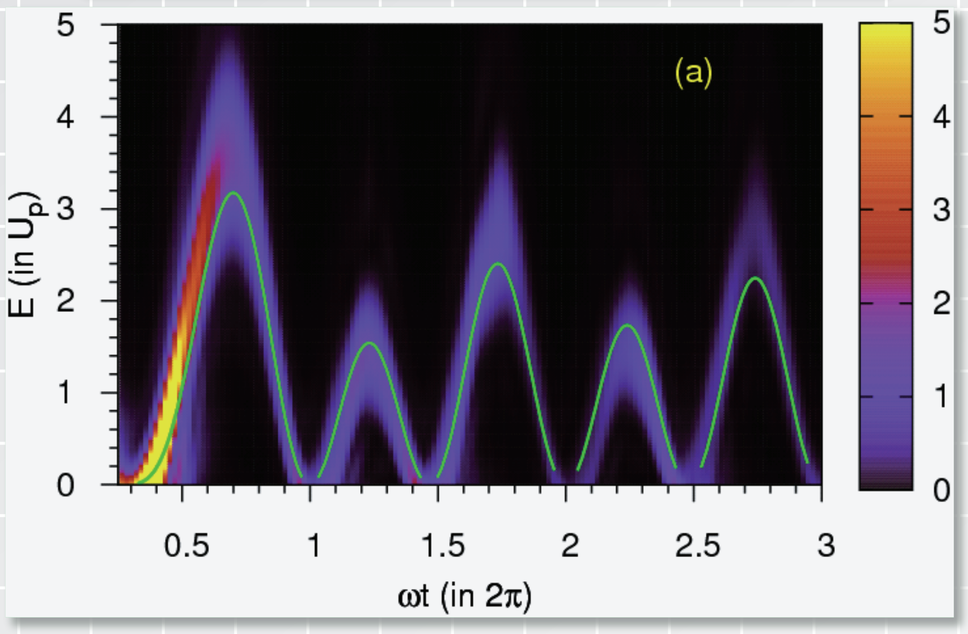
Computational Quantum Many-Body Systems

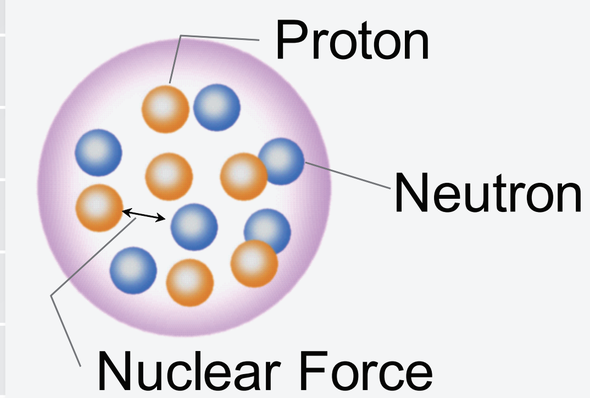
Numerical Simulation on the Intense Laser-Material Interactions

When an intense laser (>10^{14} W/cm^2) incidents on a target material, the electron will be ionized, bounced back and re-collide with the parent core as shown in the figure (upper). The rescattering electron forms a coherent, extremely intense beam, which can be used to generate an atto-second X-ray laser, and to image the molecular structures as shown in the figure (middle). For such purposes, we have to know the rescattering electron energy and time distribution. Such important information cannot be observed in the experiment since the rescattering is an intermediate process. Directly numerical simulation of this full 3-dimensional time-dependent problem is still a challenge even for the supercomputer. Using our recently developed high precision method for the time-dependent Schrodinger equation, we obtained the rescattering information as shown in the figure (bottom) for atoms. To extend the present numerical method to large molecules, we need the next generation supercomputers with parallel architectures. The study will help the experimentalists to design the future experiment to image the molecular structures.





Time-Dependent Density-Functional Theory in Atomic Nuclei



Atomic nucleus is an extremely high density matter located at the center of each atom. It is composed of protons and neutrons and is governed by the law of quantum mechanics. About 270 stable and 70 unstable nuclei exist in nature, and more than 3,000 nuclei have been synthesized artificially. To explore the properties of atomic nuclei in whole nuclear chart, a large scale computation based on the nuclear density functional theory has been successful.

The right figure shows a systematic calculation of the nuclear giant dipole resonances calculated at PACS-CS with the time-dependent density-functional theory.

The profile reflects the nuclear shape, and the strength is important to understand the origin of matter in the universe.