Two-color two-photon double ionization of Helium

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Free electron laser facilities have sprout all over the world. These light sources can produce ultrashort pulses, already in the sub-femtosecond regime, with enough intensity to induce non-linear phenomena in gas phase atoms and molecules. One of the most fundamental non-linear processes, two-photon ionization has been object of recent experiments, exploring and exploiting new aspects of well-known light-induced physical problems such as Rabi oscillations [1] or light-induced interferences leading to asymmetric photoelectron emission from simple atoms [2,3]. The present work proposes new schemes to employ these light sources to access information on dynamical electron correlation effects in double photoionization problems.

This theoretical study first explores the electron dynamics of hydrogen using strong fields that alter the molecular potential, with relatively long wavelengths, and then investigate the double ionization of helium using a two-color scheme. In the first scenario, we examine the strong variation of the ionization yield, as well as the depletion of the ground state of the H atom with the laser intensity and compare with existing data [4]. In the second scenario, although the laser intensities are large, we employ much shorter wavelengths, thus keeping the problem within a perturbative regime. We then demonstrate how the double ionization yield can be manipulated by employing a given time-delay between these pulses of different color. In both cases, we employ a numerical approach based on the numerical solution of the time-dependent Schrödinger equation (TDSE) in full dimensionality. The wave function is described using a Finite Element Method with a Discrete Variable Representation (FM-DVR), which greatly simplifies the numerical implementation. The TDSE is the solved employing a Cranck-Nicholson [5] or Lanczos propagator [6]. The scattering function, corresponding to a specific single or double ionization channel, is then extracted by an implicit propagation to infinite time using an Exterior Complex Scaling (ECS) of the electronic coordinates, followed by a Fourier transform [5,7]

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