

Time-resolved resonant photoionization of He using a time-dependent Feshbach method with ultrashort laser pulses

C. M. Granados-Castro and J. L. Sanz-Vicario¹

Grupo de Física Atómica y Molecular. Instituto de Física, Universidad de Antioquia, Medellín, Colombia.

Synopsis We study the resonant photoionization of the Helium atom subject to ultrashort laser pulses by using a Feshbach formalism in the time domain. We solve the projected time-dependent Schrödinger equation in terms of a configuration interaction spectral method, with a total wave function expanded with configurations defined within bound-like (\mathcal{Q}) and scattering-like (\mathcal{P}) halfspaces. The method allows for accurate descriptions of both the atomic structure (energy positions and widths) as well as for the resonant photodynamics using ultrashort laser pulses. Special attention is given to the temporal formation of Fano profiles in the one- and two-photon ionization cross sections.

The recent experimental development of high intensity, high frequency XUV ultrashort laser pulses down to the attosecond time scale has led to the possibility of tracing the electron photodynamics in its natural time scale [1]. The temporal behaviour of many-electron atoms subject to a strong laser field still remains a challenging theoretical problem when dealing with multiple excitation and ionization, including Auger phenomena, which requires to account for the appropriate representation of the electron correlation (responsible for the autoionization) along with the solution of the time-dependent Schrödinger equation. Among fast evolving phenomena in atomic physics, it has been of recent interest the time-resolved formation of Fano profiles in the atomic photoionization spectra, using both simplified models and *ab initio* methods [2]. In this respect, experimental attosecond resolution of the He autoionization process has been recently reported [3], demonstrating control over the two interfering paths, direct ionization and autoionization, that shape the profile of the Fano resonance.

Our work [4] describes the theoretical details and the inner workings of an *ab initio* time dependent Feshbach method [5] as applied to the resonant photoionization of He atom using ultrashort laser pulses, below the second ionization threshold. Some simple illustrations of the performance of this method are shown, like i) the time-resolved one-photon ionization below the $\text{He}^+(n=2)$ ionization threshold, from 1^1S^e and 2^1P^o initial states, then reaching the lowest autoionizing states of 1^1S^e , 1^1P^o and 1^1D^e final symmetries ii) studying the temporal formation of the Fano profile of 1^1P^o resonances (see figure 1) iii) showing its performance in obtaining the perturbative long-time limit of one- and

two-photon ionization cross sections using ultrashort laser pulses following a recently developed procedure described in [6] and iv) studying the role of resonance decay in the symmetry breaking of the photoelectron angular distributions.

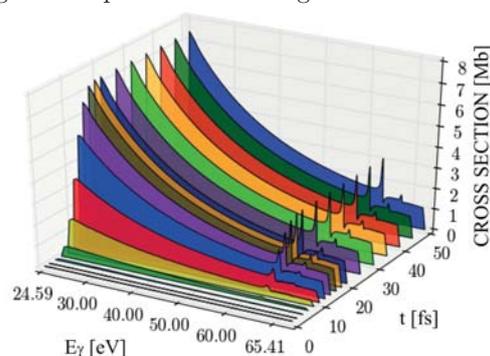


Figure 1. Temporal build-up of the Fano profiles in the one-photon photoionization cross section of He ($\text{He}[1^1S^e] + \gamma \rightarrow \text{He}^+ + e^- [1^1P^o]$) between the first and second ionization thresholds, using a laser pulse with duration $T=20$ fs.

References

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¹E-mail: sanjose@fisica.udea.edu.co

