Manipulating quantum interferences in laser dressed-helium by the transferred momentum between the electron projectile and helium target

Hicham Agueny[*][1], **Abdelkader Makhoute**[†], **and Alain Dubois**[‡]

[*]Department of Physics and Technology, Allegt. 55, University of Bergen, N-5007 Bergen, Norway
[†] UFR de Physique du Rayonnement et des Interactions Laser-Matière, Faculté des Sciences. Université Moulay Ismail, B.P. 11201, Zitoune, Meknès, Morocco
[‡] Sorbonne Universités, UPMC Univ Paris 06, UMR 7614, Laboratoire de Chimie Physique-Matière et Rayonnement, F-75231 Paris Cedex 05, France

Synopsis We present theoretical study of energetic electron-impact excitation of "six-level helium atom" embedded in a laser field. During the scattering process, the combined interactions lead to a change in the kinetic energy and the angular distribution of the scattered electron. The latter contains all information about the combined interactions. The analysis of the angular distribution reveals the emergence of a peak profile. This is will be discussed in terms of quantum-path interferences in bound-bound electronic transitions. Furthermore, the sensitivity of the phenomenon to the collision dynamics will also be discussed.

The scattering processes of electrons on atoms in the presence of a laser field, also called laser-assisted electron atom scattering, have long been recognized as a useful tool to make evident the multiphoton signals [1, 2]. The characteristics that distinguishes this class of elementary collision physics is the presence of the laser photon, which plays a role of a Ťthird bodyŤ, in addition to the electron projectile and target atom. The latter enables to control the atomic and molecular dynamics and manipulate the reaction rates by a suitable choice of laser parameters.

In this context, electronic transitions induced by a laser field can lead to new effects, which may emerge in the angular distribution of the scattered electron [3, 4]. During the conference we shall present a study of quantum-virtual path interferences produced in energetic electron-impact excitation of a helium atom embedded in a low-frequency laser field. The process under investigation is dealt with a nonperturbative approach based on Born-Floquet method [5, 4]. Under the framework of this approach, the dressed atomic states are first obtained via Floquet theory. The incoming and scattered dressed-electron projectile are described using non-relativistic Volkov solutions; while their interactions with the target are treated within the first Born approximation. Here, we will show that the observed peak profile in the angular distribution of the scattered electron (cf. Fig. 1) is a signature of quantum interference between different virtual pathways that the excitation may follow in order to end up in a common final channel. These findings are supported by additional calculations based on Kroll-Watson approximation and time-dependent perturbation theory, in which no quantum interferences are accounted for. Furthermore, the possibility of stimulating the peak profile by means of the transferred momentum between the collision partners during the scattering process will also be addressed.

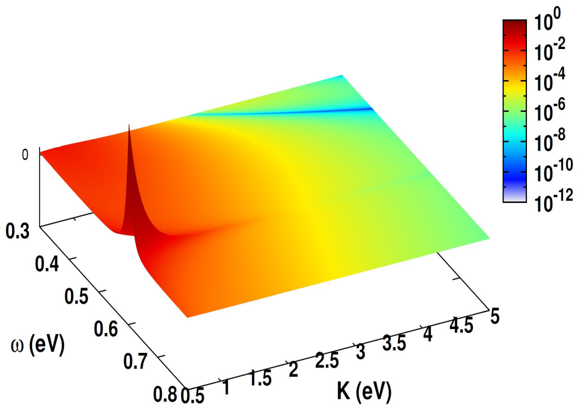

Figure 1. Angular distribution of the excitation of the dressed-state 1s2s of the helium atom for one photon emission (i.e., photon transferred between the colliding system and laser field) as a function of the transferred momentum K and the frequency ω of the laser field. The polarization of the laser field is kept along the momentum transfer. The peak intensity is fixed at 10^9 W/cm^2, the incoming electron energy is 100 eV, and the scattering angle is varied from 0 to 180°.

References

[1] D. Andrick and L. Langhans 1976, *J. Phys. B* **9** L459

[2] Y. Morimoto *et al* 2015, *Phys. Rev. Lett.* **115** 123201

[3] H. Agueny *et al* 2017, *submitted to New J. Phys.*.

[4] H. Agueny *et al* 2015, *Phys. Rev. A* **92** 013423

[5] M. Dorr *et al* 1994, *Phys. Rev. A* **49** 4852

[1]E-mail: hicham.agueny@uib.no