Polarization effects in above-threshold ionization of Mg with a mid-infrared strong laser field

Huipeng Kang*,§ [1], SongPo Xu*,†, YanLan Wang*,†, XuanYang Lai*, Thomas Pfeifer‡, XiaoJun Liu* [2], Jing Chen¶ [3], Ya Cheng&, and ZhiZhan Xu&

* State Key Laboratory of Magnetic Resonance and Atomic and Molecular Physics, Wuhan Institute of Physics and Mathematics, Chinese Academy of Sciences, Wuhan 430071 , China

† University of Chinese Academy of Sciences, Beijing 100049, China

‡Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany

§Institut für Kernphysik, Goethe Universität Frankfurt, 60438 Frankfurt am Main, Germany

¶HEDPS, Center for Applied Physics and Technology, Peking University, Beijing 100084, China and Institute of Applied Physics and computational Mathematics, P. O. Box 8009, Beijing 100088, China

&State Key Laboratory of High Field Laser Physics, Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, P. O. Box 800-211, Shanghai 201800, China

Synopsis Using a semiclassical approach, we find an enhancement of low-energy structure in above-threshold ionization spectra of Magnesium by intense, mid-infrared laser pulses. By performing electron trajectory and recollision-time distribution analysis, we demonstrate this enhancement results from a focusing of electrons by laser induced dynamical polarization.

Along with the advances in generation of tunable long-wavelength intense laser pulses, experimental studies revealed novel features of above-threshold ionization (ATI) electrons deeply in the tunneling ionization regime [1]. One is the surprising bump appearing in the low-energy part of photoelectron energy spectra (PES), coined as “low-energy structure” (LES) [1, 2]. It’s well known now that the LES can be attributed to the Coulomb focusing of outgoing electrons by the parent ion. However, so far our understanding relies on the single-active electron (SAE) approximation. In this contribution, we theoretically investigate the ATI of Magnesium with mid-infrared (~2000 nm) strong laser fields using a semiclassical approach [3], with the purpose of studying multielectron effects beyond the SAE picture.

Figure 1(a) displays our calculated PES of Mg at an intensity of 3×10^{13} W/cm^2. In addtion, we also calculated the corresponding spectrum based on SAE approximation in Fig. 1(b). It is noteworthy that the relative yield of the LES is clearly enhanced when including the multielectron effects, irrespective of the decreased absolute counts. In Figs. 1(c) and 1(d), we present the normalized angular distributions of the electrons that belong to the energy range of LES in Figs. 1(a) and 1(b), respectively. The calculated results show that the distribution becomes narrow with the multielectron effects taken into account, implying additional ionic focusing effect on LES other than Coulomb focusing effect.

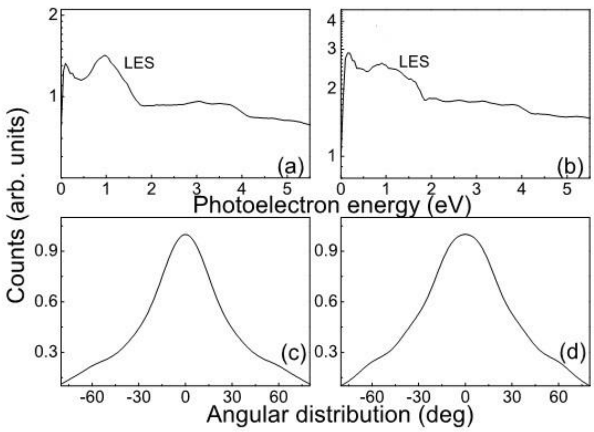

Figure 1. (a) Calculated PES of Mg at an intensity of 3×10^{13} W/cm^2 and a wavelength of 2000 nm. (b) Corresponding spectrum based on SAE approximation. The laser parameters are the same as in (a). (c), (d) Normalized angular distributions of electrons that contribute to the energy range of LES in (a) and (b), respectively.

To uncover the underlying mechanism, we analyze the recollision-time distribution and electron trajectory for the SAE and the multielectron case. We find the confining electrons by the dynamical dipole potential facilitate the recollision process, and thus the production of LES.

References

[1] C. I. Blaga *et al.* 2009 *Nat. Phys.* **5** 335

[2] W. Quan *et al.* 2009 *Phys. Rev. Lett.* **103** 093001

[3] N. I. Shvetsov-Shilovski *et al.* 2012 *Phys. Rev. A* **85** 023428

[1] E-mail: kang@atom.uni-frankfurt.de

[2] E-mail: xjliu@wipm.ac.cn

[3] E-mail: chenjing@iapcm.ac.cn