# Influence of the delay and relative polarization in photoionization of water by laser-assisted attopulse trains

**L. Martini**[*1], **D.I.R Boll**[*2], **O.A. Fojón**[*†3]

[*] Laboratorio de Colisiones Atómicas, Instituto de Física Rosario (CONICET-UNR), Rosario, Santa Fe 2000, Argentina.
[†] Dpto. de Química, Facultad de Ciencias, Universidad Autónoma de Madrid, Madrid, España.

**Synopsis** We study theoretically the photoionization of water molecules by extreme ultraviolet attopulses (or train of attopulses) assisted by a near infrared laser both with linear polarizations. We employ a separable Coulomb-Volkov model [1, 2, 3, 4, 5, 6] to describe the reaction. We analyze the effects of different delays and relative polarizations between the attopulse and the assistant laser field on the dressed harmonics lines.

The knowledge of ionization of water molecules is relevant in several domains such as astrophysics, radiobiology and medical physics. For instance, this basic reactions is essential to understand the interaction between radiation and the biological tissue because living cells are composed mostly by water. Therefore, we study theoretically the photoionization of water molecules by extreme ultraviolet attopulse trains assisted by lasers in the near-infrared range.

To describe the reaction, we employ a separable Coulomb-Volkov (SCV) model [1, 2, 3, 4, 5, 6] in which the temporal evolution of the system can be divided into three stages allowing spatial and temporal separation for the Coulomb and Volkov final state wavefunctions. In fact, the final state is described by a product of a Coulomb wave and a Volkov function. The first one describes the interaction of the photoelectron with the residual target whereas the Volkov function takes into account the action of the assistant laser on the photoelectron to all orders. Employing previous analytical expressions deduced from the SCV model [4, 5], we obtain angular distributions of photoelectrons for linear polarization for both the attopulses and the assistant laser.

First, we analyze the influence of the delay between the attopulse and the assistant laser field on the dressed harmonics lines. The water molecule bound states are represented using the Moccia's monocentric wavefunctions [7]. We compare our results for water and Ne atoms as they belong to the same isoelectronic series. As no experiments are available for water, we contrast our calculations also with previous theoretical and experimental work for Ar atoms [5] due to the similarities of the orbitals involved in the reaction. Second, we study the effect of varying the relative orientations of the attopulse and laser field polarizations and we compare our predictions with other theories and experiments [8].

We hope our work contribute to the improvement of polarization experiments and the development of the attopulse trains and assistant laser fields technologies. Finally, we expect that these studies promote progress on the control of the chemical reactivity of water molecules since this could be helpful in many fields as the ones above mentioned.

## References

[1] G. L. Yudin, S. Patchkovskii and A. D. Bandrauk. 2006 *J. Phys. B: At. Mol. Opt. Phys.* **39** 1537-1546

[2] G. L. Yudin, S. Chelkowski and A. D. Bandrauk. 2006 *J. Phys. B: At. Mol. Opt. Phys.* **39** L17-L24

[3] G. L. Yudin, S. Patchkovskii, P. B. Corkum and A. D. Bandrauk. 2007 *J. Phys. B: At. Mol. Opt. Phys.* **40** F93-F103

[4] D. I. R. Boll and O. Fojón. 2014 *Phys. Rev. A* **90** 053414

[5] D. I. R. Boll and O. Fojón. 2016 *J. Phys. B: At. Mol. Opt. Phys.* **49** 185601

[6] D. I. R. Boll and O. Fojón. 2017 *J. Phys. B: At. Mol. Opt. Phys.* **50** 055604

[7] R. Moccia. 1964 *J.Chem. Phys.* **40** 2186

[8] T. Leitner, R. Taïeb, M. Meyer and P. Wernet. 2015 *Phys. Rev. A* **91** 063411

[1]E-mail: martini@ifir-conicet.gov.ar
[2]E-mail: boll@ifir-conicet.gov.ar
[3]E-mail: fojon@ifir-conicet.gov.ar