G M Laurent, J Astrophys Aerospace Technol 2017, 5:2 (Suppl)
DOI: 10.4172/2329-6542-C1-008

Optical control of electron emission at the attosecond timescale

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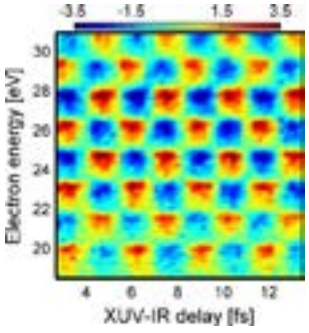
Coherent control of electron dynamics in matter is a growing research field in ultrafast science, which has been mainly driven over the last two decades by major advances in laser technology. Recently, the advent of extreme-ultraviolet (EUV) light pulses in the attosecond time scale ($1as=10^{-18}s$) has opened up new avenues for experimentalists to manipulate the electronic dynamics with unprecedented precision. In this work, we demonstrate that an asymmetric electron emission from atomic targets can be generated and controlled by combining an attosecond pulse train (APT) composed of both odd and even harmonics and a weak IR field ($10^{11}W/cm^2$). Electron wave-packets are formed by ionizing argon gas with such APT in the presence of the IR field. Consequently, a mix of energy-degenerate even (*s,d*) and odd (*p,f*) parity states is fed into the continuum by one- and two-photon transitions. These interfere, leading to an asymmetric electron emission along the polarization vector. At some appropriate time delay between the APT and IR fields, the even and odd angular continuum wave function resulting from one and two-photon transitions, respectively, add constructively on one side (up) of the polarization vector direction and destructively on the other side (down), thus creating a strong up-down asymmetry in the angular emission of the photoelectrons. The direction of the emission can be controlled by varying the time delay between the two pulses. In addition, we show that such asymmetric emission is also related to the properties of the APT. The temporal analysis of the modulated electron emission, based on an accurate description of the atomic physics of the photoionization process, then provides a way to measure the temporal profile of the attosecond pulse. We propose a retrieval procedure which allows for the unique determination of the spectral phase making up the pulses. The procedure had been demonstrated for the characterization of an attosecond pulse train composed of odd and even harmonics. We observe a large phase shift between consecutive harmonics. Our results contradicts the generally accepted physical picture that the combination of even and odd harmonics in the train necessarily creates a series of pulses which occur only once per IR cycle. This picture holds only if there is no phase shift between even and odd harmonics. Otherwise, the resulting APT has a more complex structure not resembling a single AP once per IR period.



Asymmetry of electron emission from argon as a function of electron energy and delay between the attosecond pulse and the femtosecond IR field.

Biography

G M Laurent is an expert in Atomic and Molecular Physics. He received his PhD in 2004 from the University of Caen (France). He was a Post-doctoral fellow at the University of Madrid in Spain. In 2009, he joined the Physics Department at Kansas State University as a Research Associate, where he started his research in the field of attosecond science. In 2013, he moved to MIT as a Research Scientist to pursue his research in attosecond science and femtosecond laser development. Finally, in fall 2015 he joined the Physics Department at Auburn University as an Associate Professor.

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