Coherent Control and Attosecond Dynamics with Pulsed XUV and IR Radiation

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The enormous advances in the generation of advanced light sources have enabled the exploration of the ultrafast dynamics in atoms and molecules, thereby promising a rich field of possibilities in the control of matter. One aim of quantum coherent control is to steer electronic motion in atoms and molecules in specific directions or locations. Recently, experimental manipulation of the photoelectron angular distribution (PAD) was achieved using the Free-Electron Laser (FEL) at FERMI in Trieste (Italy) by controlling the relative time-delay between the fundamental and second harmonic of a linearly polarized femtosecond extreme ultraviolet (XUV) pulse to an unprecedented precision of three attoseconds. [1]

We present a variety of schemes by which control of the PAD asymmetry can be achieved, such as interfering one-photon and two-photon ionization pathways in a region of an intermediate resonance, overlapping the XUV pulse with an infrared (IR) field, or using circularly polarized light. Employing circularly polarized light opens up a number of particularly interesting possibilities in the study of multi-photon ionization processes. For example, a circular dichroism is revealed in an ionization scheme for which an XUV pulse ionizes helium and then sequentially pumps the remaining electron to an oriented excited state of He^+, while an overlapping optical field, which can either be co-rotating or counter-rotating with respect to the XUV field, further ionizes the residual He^+ ion via multiphoton absorption [2].

Few-cycle elliptically polarized pulses can be employed in so-called "attoclock experiments" to investigate the tunneling time in strong-field ionization to test the claim that tunneling ionization in atomic hydrogen is instantaneous [3]. Recently, we used a one-dimensional model with linearly polarized light in a short-range Yukawa potential to show that the often-used picture of a probability flow traversing the entire barrier from the inner to the outer classically allowed regions is fundamentally flawed [4]. An update on the latest development, an experimental attoclock experiment on atomic hydrogen [5], will also be presented.

[1] K. C. Prince *et al*., Nature Photonics **81** (2016) 043408.
[2] M. Ilchen *et al*., Phys. Rev. Lett. **118** (2017) 013002.
[3] L. Torlina *et al*., Nature Physics **11** (2015) 502.
[4] N. Douguet and K. Bartschat, Phys. Rev. A **97** (2018) 013402.
[5] Satya Sainadh *et al*., arXiv 1707.05445 (2018).

Bio: Klaus Bartschat is the Ellis & Nelle Levitt Distinguished Professor of Physics at Drake University. He received the Diploma (Masters) in Experimental Physics in 1981, the Dr. rer. nat. (Ph.D.) in Theoretical Physics in 1984, and the Habilitation for Physics in 1989 from the University of Münster (Germany). Since joining the faculty of Drake University in 1988, he has been a Visiting Fellow at the Joint Institute for Laboratory Astrophysics at the University of Colorado in Boulder and the Institute for Atomic, Molecular, and Optical Physics at the Harvard Smithsonian Center for Astrophysics. He held a Mercator Professorship at the University of Münster and Adjunct Professorships at several universities in Australia. Bartschat was elected to Fellowship in the American Physical Society in 1998. He has published three books, over 50 book chapters, 15 invited reviews, and about 400 papers in peer-reviewed journals. In 2016, he was awarded the Will Allis Prize of the American Physical Society for *"fundamental theoretical and computational contributions to the understanding of charged-particle and photon collisions with atoms and molecules and for providing critical data and insight to the plasma modeling community"*.