

Creating coherent hole wave packets with strong-field pulses

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Synopsis A new approach is identified that can generate highly coherent hole wave packets with multi-cycle strong-field pulses and stands in contrast to the usual idea of making the ionizing pulse as short as possible. The effect is demonstrated in atomic xenon with a spin-orbit wave packet involving the $5p_{3/2}^{-1}$ and $5p_{1/2}^{-1}$ ionic states. Tuning the driving frequency to an even fraction of the hole oscillation frequency ensures the creation of highly coherent holes.

Creating coherent electronic motion in atoms and molecules on ultrafast time scale is as exciting as challenging [1]. One specific type of electronic motion, which has attracted wide interest in the attosecond community, is hole migration [2]. By photoionization, an electronic hole motion can be triggered that moves within the parent system on a sub- to few-femtosecond timescale [2].

The hole generation process is often greatly simplified by exploiting the sudden approximation, which states that an electron is instantly removed from one specific state. Ionizing an electron with an attosecond or strong-field pulse can become a complex process for itself. Mechanisms such as interchannel coupling can very fast turn photoionization into a true many-body process. The coherence in the hole state that one wanted to create could be lost due to interchannel effects [3]. A coherent hole wave packet is, however, needed to see the subsequent hole migration dynamics.

Here, we proposed an alternative approach to create coherent hole wave packet that does not rely on attosecond XUV [3] or sub-cycle IR [4] pulses, which are very hard to generate. The main idea of this approach is that the system gets only ionized when the hole returns to its initial form. In this way, the hole creation is "in phase" with the hole oscillation. This ensures that the final hole state is fully coherent. In other words, the driving frequency ω of the pulse should be an even fraction of the hole oscillation frequency ΔE , i.e., $\Delta E = 2n\omega$. In Fig. 1 the hole coherence between $5p_{3/2}^{-1}$ and $5p_{1/2}^{-1}$ in xenon ($\Delta E = 1.3$ eV) is shown as a function of pulse duration and wavelength.

Besides the hole coherence, also the hole pop-

ulation is affected by ω . An enhanced hole population can be found when the system gets ionized "in phase" with the hole motion—exactly at the same frequencies as the maximum hole coherences are reached.

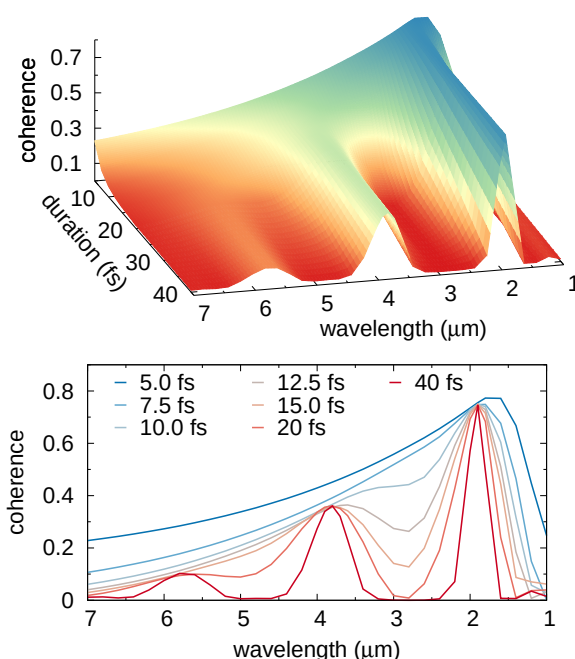


Figure 1. Hole coherence between the two ionic states $5p_{3/2}^{-1}$ and $5p_{1/2}^{-1}$ as function of pulse duration and wavelength.

References

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