Attosecond Control in Photoionization of D₂

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Attosecond Control in Photoionization of D$_2$

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Synopsis

We study the dissociative photoionization of D$_2$ by an attosecond pulse train (APT) in the presence of a near-infrared (IR) field. Strong oscillations in the D$^+$ kinetic energy release spectrum with a half period of the optical cycle of the infrared field are observed and attributed to interferences between ionization pathways involving different harmonic orders of the APT due to the IR-induced coupling between the 1s$_g$ and 2p$_u$ ionization channels.

With the advent of time-resolved spectroscopy with attosecond resolution, ultrafast electron dynamics in atoms and molecules becomes an attractive field of research. Attosecond spectroscopy is based on the generation of attosecond light pulses by using high-order harmonic generation (HHG). Nowadays, attosecond pulses are generated in the form of attosecond pulse trains (APT) [1] as well as isolated attosecond pulses [2]. Successful applications of attosecond spectroscopy in atoms [3] and, more recently, in molecules [4] have been demonstrated. In our previous work [4], electron localization in the ion fragments was resolved with attosecond resolution in the dissociative photoionization of H$_2$, initiated by a single attosecond pulse and probed by a few-cycle infrared (IR) field.

Here we use instead an APT laser pumping, built from odd harmonics H$_{11}$ to H$_{27}$ (centered at H$_{19}$) of a parent 780 nm IR field, and report the effects on the kinetic energy release (KER) spectrum for D$^+$ fragments ejected along the laser polarizator axis. Strong oscillations in the fragment ion yields as a function of the pump-probe time delay are observed and confirmed by theoretical calculations (Figure 1). The APT firstly ionizes D$_2$ into continuum states of both 1s$_g$ and 2p$_u$ channels located at the IR-odd harmonics. Q$_1$S$^+_u$, doubly excited states are also simultaneously excited. The delayed IR field then couples continuum states, within the same ionization channel or between different channels.

The absorption/emission due to 1s$_g \rightarrow$ 2p$_u$ IR-couplings results in RABBITT-like sidebands located at the even harmonics in the photoelectron spectrum. Oscillations in the D$^+$ KER are explained in terms of quantum interferences between ionization pathways contributing to these sidebands.

![Figure 1](image-url)  

Figure 1. D$^+$ KER spectrum as a function of the delay between the APT and the IR pulse. (a) Experiment (b) Theory.

References