Probing Hydrogen and Deuterium Molecular Dynamics Using Attosecond Transient Absorption

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Abstract: Few-cycle laser induced dynamics in the $D^1\Pi_u \leftarrow X^1\Sigma_g$ and $C^1\Pi_u \leftarrow X^1\Sigma_g$ bands of vibrational wavepacket of hydrogen and deuterium molecules are studied by the attosecond transient absorption spectroscopy.
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1. Introduction

One of the most fundamental goals of attosecond science is to understand and to control the dynamic evolution of electrons in matter. Attosecond transient absorption spectroscopy [1] is a powerful method which can uncover the fastest dynamics of electrons in atoms and molecules. Here we apply the attosecond transient absorption spectroscopy technique to study the electron dynamics in bound states of hydrogen and deuterium molecules.

2. Experiments and discussion

The experiment was conducted by using the attosecond transient absorption technique. The 0.7 *mJ*, 5 *fs* near infrared (NIR) pulses centered at 730 *nm* were split in to two parts. Isolated attosecond pulses with spectrum ranging from 12 to 17 *eV* were generated by utilizing the generalized double optical gating technique [2] with half of the NIR driving pulses. An indium foil filter was used to block the residual driving laser. The transmitted XUV spectrum was measured as a function of the time delay between the attosecond pulse and the NIR laser.

Figure 1(a) shows the transmitted XUV spectrum of hydrogen as a function of the time delay between the attosecond XUV pulse and the NIR laser pulse. Negative delays indicate that the attosecond pulse arrives on the target before the NIR laser. The $D^1\Pi_u \leftarrow X^1\Sigma_g$ and $C^1\Pi_u \leftarrow X^1\Sigma_g$ bands of vibrational states were observed to change dramatically in the presence of the NIR laser. Additionally, we find that the absorption structures are different for positive and negative delays. In figure 1(b), the integrated transmitted XUV signal in the vicinity of the $C^1\Pi_u$ state is plotted as a function of the delay. A sigmoidal fit yields a time constant of ~7.3 fs for the increase in the transmission of deuterium molecules and of 3.7 fs for the hydrogen molecules, indicating a clear isotope effect.

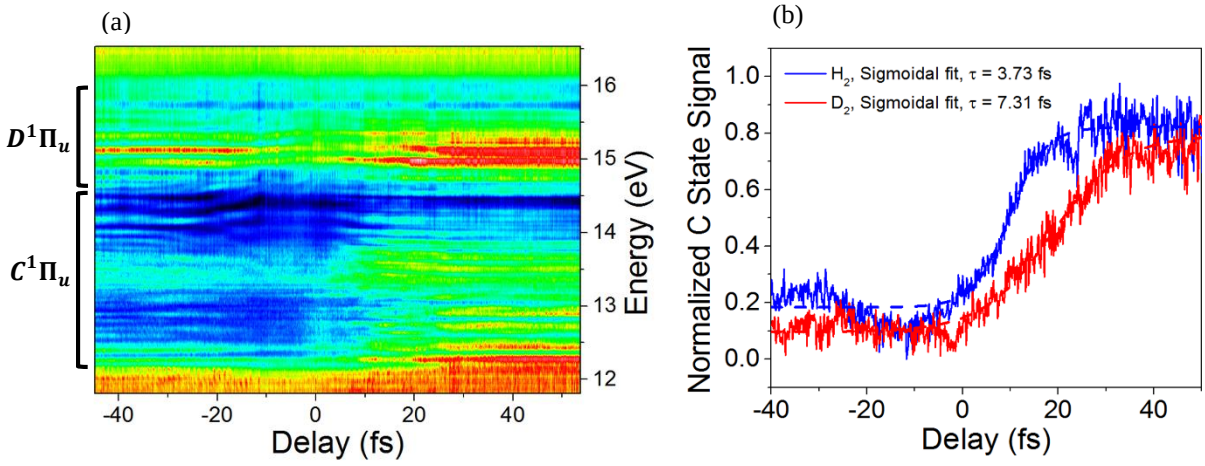

Fig. 1. (a) Transmitted attosecond XUV spectrum of H_2 as a function of time delay.
(b) Normalized $C^1\Pi_u$ state signal as a function of time delay

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3. References

[1] M. Chini *et al.*, "Sub-cycle Oscillations in Virtual States Brought to Light," Sci. Rep **3,** 1105 (2013).

[2] X. Feng *et al*., "Generation of Isolated Attosecond Pulses with 20 to 28 Femtosecond Lasers," Phys. Rev. Lett. **103**, 183901 (2009).