Zero Photon Dissociation of H_2^+ in Few Cycle Pulses

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Synopsis Evidence for dissociation caused by an intense laser field with the net absorption of zero photons is conflicting. We have measured very low kinetic energy release upon H_2^+ dissociation in few cycle pulses – a signature of zero photon dissociation. Comparison with solutions of the time dependent Schrödinger equation supports this assertion.

At this conference we will focus on the zero photon dissociation (ZPD) of H_2^+ in few cycle laser pulses. This mechanism is illustrated in Fig. 1. At the beginning of the pulse the field is weak and the potential energy curves $|1s\sigma_g\text{-}0\omega>$ and $|2p\sigma_u\text{-}1\omega>$ are diabatic. In the leading edge of the pulse, as intensity increases, the coupling becomes stronger and the curves can be considered as adiabatic. In this case there is a potential well just above the crossing, which "traps" part of the wavepacket corresponding to the vibrational levels in this region of the well and is called vibrational trapping (VT). Later in the pulse, some of the trapped wavepacket will spill over the well and onto the $|1s\sigma_g\text{-}0\omega>$ curve. The net number of photons absorbed in this process is zero and hence the name zero photon dissociation. The kinetic energy release (KER) in this process is very low and also depends on how fast the field of the pulse is changing.

This ZPD effect has been observed in the dissociation of the H_2^+ with 266 nm pulses of width about 250 fs [1]. However, recently the same authors [2] have given an alternative explanation for the low KER observed in Ref. [1]. Our calculations also suggest that for the pulse length used in Ref.[1], the ZPD mechanism might be too weak to be observed.

We will discuss our results of H_2^+ dissociation in intense (up to 10^{15} W/cm^2), few cycle (about 10 fs) 800 nm laser pulses. The experimental set up is a modified version of our coincidence 3D imaging apparatus used in our other studies [3]. This modified system allows us to separate the fragments that have very low KER down to zero eV, in time and position. We compare these results with theoretical calculations obtained by solving the time dependent Schrödinger equation in the Born-Oppenheimer representation and find favorable agreement.

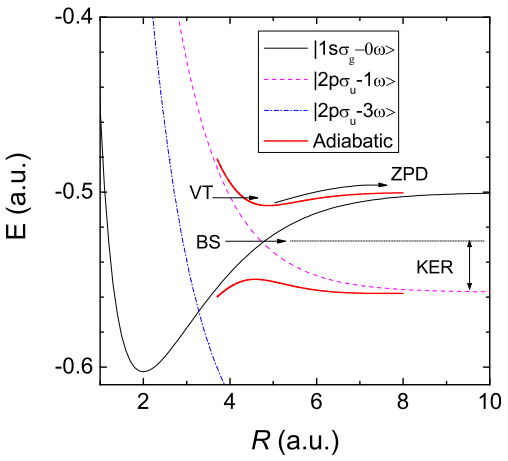

Fig. 1. H_2^+ potentials dressed by net absorbed number of photons, $n\omega$. Also indicated are the zero photon dissociation (ZPD), vibrational trapping (VT), and bond softening (BS) mechanisms.

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References

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