

Imaging molecular bond breaking with one electron

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We will describe our recent experiments to reveal molecular structural dynamics on the picometer spatial and attosecond temporal scales. To achieve this goal, we implemented mid-IR-driven laser-induced electron diffraction (LIED) [1] in combination with coincidence detection. The mid-IR radiation accelerates rescattering electrons to core-penetrating velocities while keeping the ionization fraction low. The reaction microscope permits coincident detection of fragments, and hence the identification of a specific fragmentation channel. Our methodology allowed extracting multiple bond lengths in isolated oxygen and acetylene molecules (C_2H_2) [2]. We will also show how the method can leverage the intrinsic temporal resolution of attosecond-duration rescattering wavepackets to image the deprotonation channel $C_2H_2^{++} \rightarrow H^+ + C_2H^+$. Selecting the specific channel, we demonstrate imaging of bond scission in real time and real space. The snapshots of the spatiotemporal structure were taken

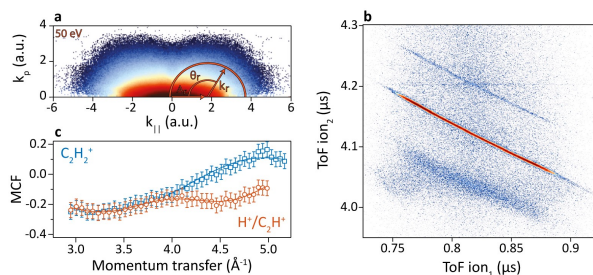


Figure 1. (a) 3D electron momentum distribution of C_2H_2 ; (b) PiPiCo of the deprotonation reaction products of C_2H_2 , (c) molecular contrast factors (MCFs).

with an estimated 0.6-fs temporal resolution and could distinguish the different kinetic behaviours of the molecule when field-ionized parallel or perpendicular to the LIED field. Moreover, changing the orientation of the molecule, we captured different dynamics and showed that the perpendicular case reveals the molecular structure in a quasi-field-free scenario for the dissociative dication.

References

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