

Ultrafast Charge Migration in a Biomolecule

Louise Belshaw¹, Francesca Calegari^{2,3}, Martin J. Duffy¹, Andrea Trabattoni², Luca Poletto³, Mauro Nisoli², and Jason B. Greenwood¹.

¹Centre for Plasma Physics, School of Maths and Physics, Queen's University Belfast, U.K.

²Politecnico di Milano, Department of Physics, CNR-IFN, Milan, Italy.

³Institute of Photonics and Nanotechnologies, CNR-IFN, Milan, Italy.

lbelshaw01@qub.ac.uk

The development of ultrafast attosecond pulses has recently opened up studies of time-resolved electron dynamics [1,2]. This burgeoning field of attosecond science not only allows the observation of dynamical processes, but also holds the promise of controlling electrons in natural and man-made molecules and nanostructures. Such control is crucial for developing technological processes based on quantum systems and for the understanding of biological processes such as photosynthesis, vision, and DNA damage and repair.

We present here the first experimental observation of ultrafast charge migration in a biological molecule - the amino acid, phenylalanine. Clean, neutral gas phase plumes of phenylalanine were produced using laser induced acoustic desorption (LIAD) [3]. An electron hole was created in the phenylalanine molecules following ionisation by a pair of attosecond extreme ultraviolet (XUV) pulses, separated by 1.5 fs. By using a few-cycle, 6 fs, visible/near-infrared (VIS/NIR) pulse as a probe at a variable time delay after ionisation, the positive charge was observed to migrate to one end of the cation within 30 fs [4]. This was achieved by observing the yield of a doubly charged ion which was sensitive to the location of the hole initially generated by the XUV pulse (Figure 1).

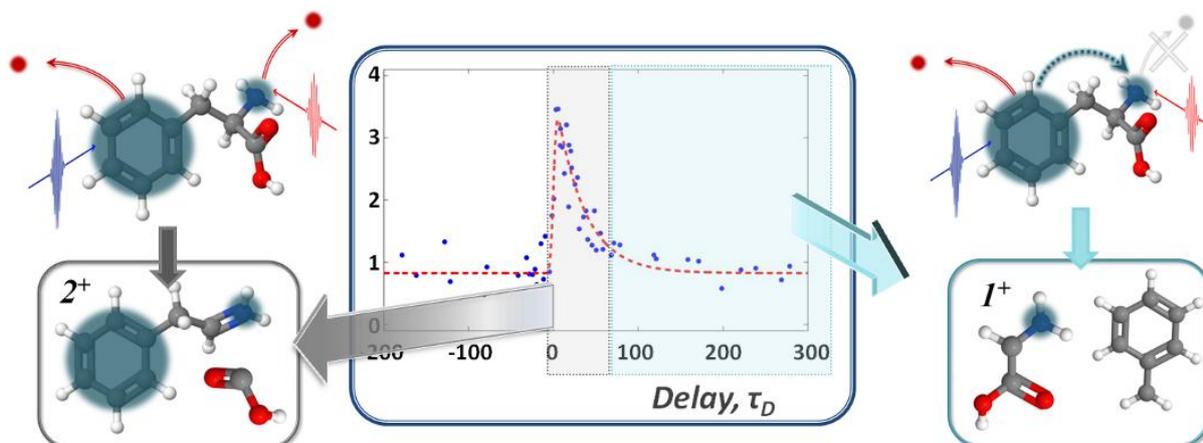


Figure 1: The yield of doubly charged immonium ions produced from single ionisation by each of the pump (XUV) and probe (VIS/NIR) pulses with respect to their delay time. Charge migration is observed to suppress ionisation by the probe.

These results are consistent with a model of ultrafast coherent where a charge wavepacket oscillates to and from one end of the cation before being modified by nuclear re-arrangement and localising in its final position. Therefore, this scheme provides a powerful template for validating the principles of ultrafast, intra-molecular charge migration.

References:

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